Product Engineering

THE McGRAW-HILL MAGAZINE OF DESIGN ENGINEERING

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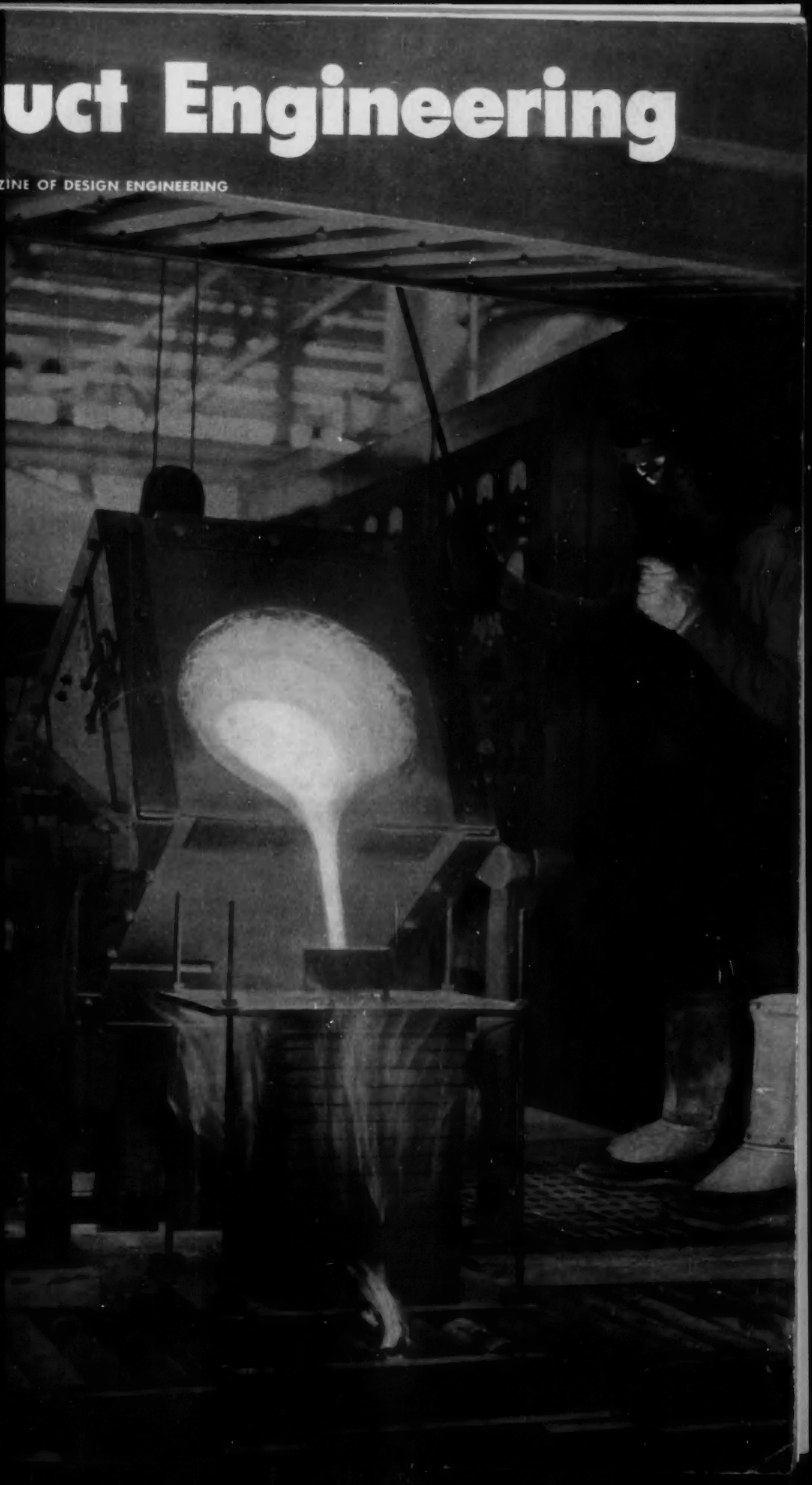

MARCH
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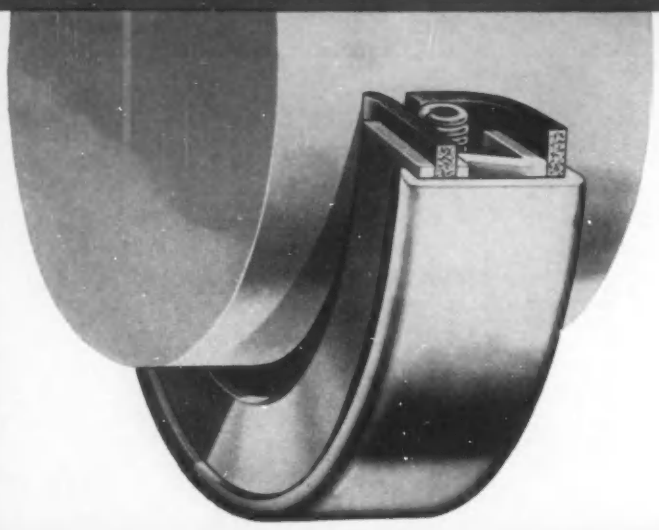

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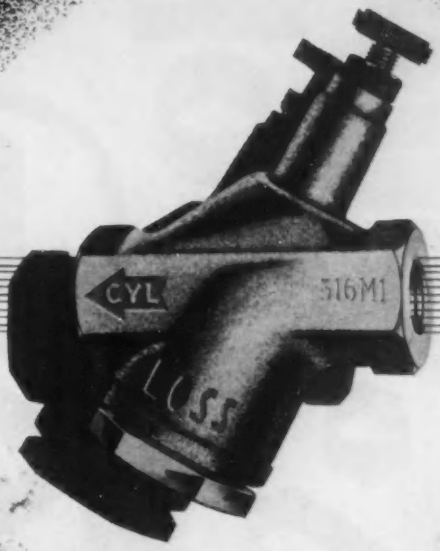

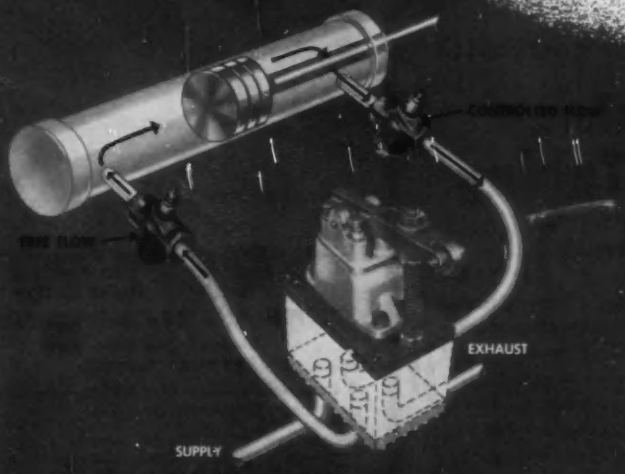

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Product Engineering

MARCH, 1954

Volume 25 Number 3

Two-Cycle Engines for Portable Power ..... Robert G. Krueger 129

Evaluation of Casting Processes ..... P. W. Beamer and S. C. Tingquist 139

New Trends in Appliance Design 145

Selecting Rotary Oil-Hydraulic Motors ..... Milton R. Fox 168

Paint Specifications for Metal Products ..... Paul E. Marling 173

Which Type Thermistor? ..... Frank K. Bennett 182

Coupling of Parallel Shafts ..... H. G. Conway 186

Solid Film Lubrication ..... Ernest Rabinowicz 188

Perforated Materials for Functional Uses ..... Foye P. Hutchinson 193

Scale Factors for Analog Computers ..... James B. Reswick 197

Balanced Design for Case-Hardened Gears ..... John Maddock 202

Spring Design Data ..... Harold C. R. Carlson 217

Patent Counsel ..... Calvin D. MacCracken and James M. Relph 281

Highlights 5
Design Perspectives... 123
Editorial 127
Technical News 208
New Parts and Materials 222
Meetings 262
New Catalogs and Bulletins 264
Sans, Souci 276
Engineering Abstracts. 286
Readers Letters 299
New Books 306

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MARCH, 1954 VOL. 25, NO. 3

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THIS MONTH'S COVER

Permanent magnets have replaced electromagnets in many applications because of recently developed, high coercive strength materials that permit designs that are smaller, less expensive and more effective than electromagnets. Alnico, the first of such materials, is still one of the most popular. To keep pace with increased demand, Carboloy Division of the General Electric Company has just opened a new permanent magnet plant at Edmore, Mich. Most colorful process in the Edmore production line is the pouring of the carefully compounded alloy into green sand molds, stacked eight high for increased production. To maintain strict control of the alloy, heats are limited to about 400 lb of metal.

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Highlights

When requesting further information from companies and organizations mentioned in the items below, confusion can be avoided by referring to the issue of Product Engineering in which items appear.

METALLIC MATERIALS

. . . . A new casting alloy, designated NA22H, which contains 48 percent Ni, 28 percent Cr, 5 percent W and 0.5 percent C, is claimed to be suitable for use at temperatures up to 2,200 F. Blaw-Knox Co., Pittsburgh, Pa., reports applications appear to be for radiant heating tubes, retorts, muffles and similar parts. The alloy can be welded with coated rods of the same composition using direct current.

HIGH-STRENGTH WELDING STEEL . . . .

. . . . A high-strength steel that, it is claimed, will withstand stresses two to three times greater than those permissible for mild steels is a development of the United Steel Companies, Sheffield, England. Boron is added to a low carbon molybdenum steel and, when present in the correct proportion, the yield point of a low carbon steel is doubled without heat treating. The steel is also said to be particularly useful for highly stressed welded structures, either at ordinary or elevated temperatures up to 450-500 Centigrade.

ALUMINUM FOR MOTORS . . . .

. . . . Squirrel cage motors using aluminum windings instead of copper windings are undergoing tests at Westinghouse Electric Corp., Pittsburgh, Pa. Reports indicate that the performance of the aluminum wound motors compares favorably with copper wound units. Lower conductivity of aluminum called for an increase in cross section, but tighter packing allowed frame sizes for a given rating to remain the same.

SPECIAL GRADE STEEL . . . .

. . . . A new grade of stainless steel, suitable for structural and other uses not dependent on cold rolling for tensile strength, is being developed. Allegheny Ludlum Steel Corp., Pittsburgh, Pa., believes the steel will find widespread uses in industry, particularly in the chemical process field. Other applications are being studied for the material in related fields.

TUNGSTEN THERMOMETERS . . . .

. . . . Tungsten is being tested to replace platinum in electric thermometers used in industry to measure high heats. G. E. reports that since platinum's upper heat-measuring limit is about 1,080 F and tungsten's is about 1,800 F, the new type of resistance thermometer will be able to check heats greater than those that can now be measured by ordinary resistance units. The supply of tungsten is readily available in the form of high purity ductile wire drawn for light bulb filaments and heating coils.

NEW ELEMENTS . . . .

. . . . Element 99 has recently been produced in sufficient quantity for chemical identification. Produced in the University of California cyclotron at Berkeley, the element has an atomic weight of 247. It is radioactive and short lived—in a few minutes it changes into element No. 97. It is not fissionable. The element is tentatively named ekaholmium, because it is related to element No. 67, holmium, in the periodic table.

NONMETALLIC MATERIALS

. . . . A new starting aid gives heavy duty combustion engines a faster start in cold weather, as low as minus 65 F. Developed by the California Oil Co., Barber, N. J., the starting unit uses a highly combustible fluid. When the engine is started the fluid is fed to it and keeps the engine running until the normal operating temperature is reached. Engine is then switched over to the regular fuel without engine shut-down.

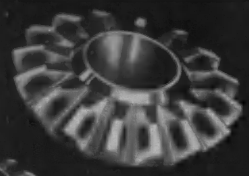
MOLDING RESIN . . . .

. . . . A thermosetting molding material with improved arc resistance and excellent dimensional stability has recently been developed. Monsanto Chemical Co., Springfield, Mass., claims that the material combines the electrical and physical characteristics most often demanded by end users of arc resistant parts. Arc resistance has been measured at 184 sec in standard ASTM tests. The problem of after-shrinkage has been virtually eliminated by good dimensional stability.

PLASTIC PIPE . . . .

. . . . Two years of field-testing by several major oil companies has shown the advantage of plastic pipe over metal pipe in such applications as salt water disposal and sour oil gathering lines and where severe corrosive conditions exist. Fibercast Corp., a division of Youngstown Sheet and Tube Co., reports that

(continued on page 7)



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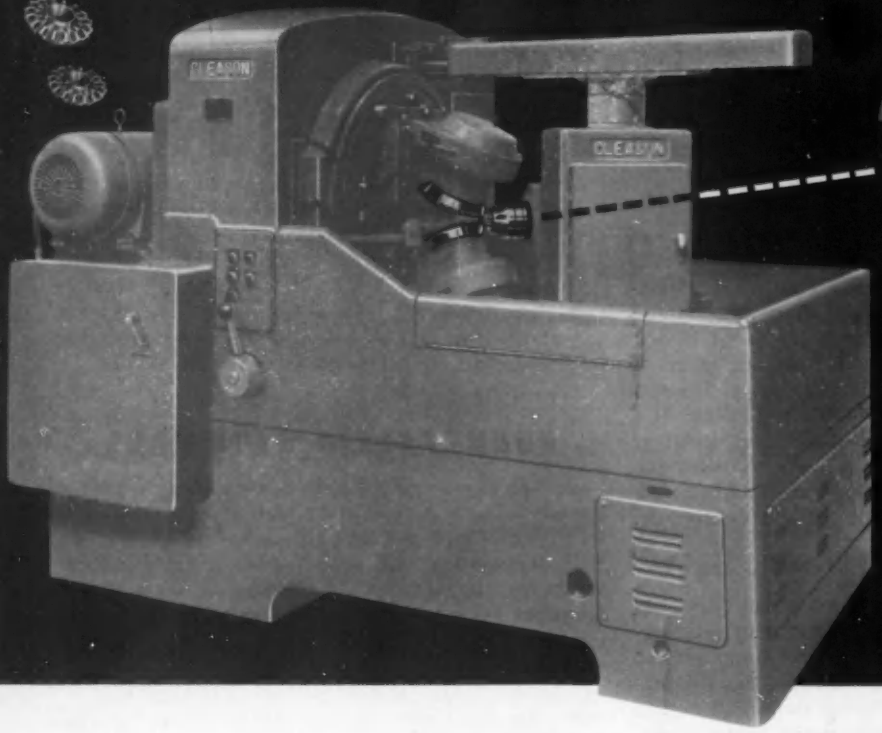

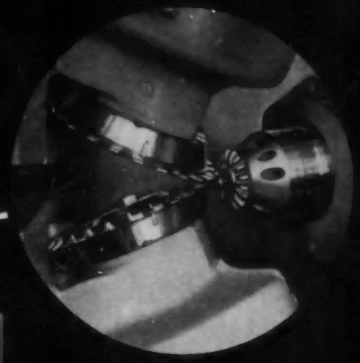

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laboratory tests indicate the pipe will withstand stresses of 10,000 psi, and high burst, collapse and beam strengths are also indicated. Fibercast produces a centrifugally-molded pipe of Bakelite polyester resins and Fiberglas mat.

ANTI-STATIC COATING ....

. . . . An anti-static coating is under development, designed to prevent communication failures caused by accumulated electrical charges on glass and plastic aircraft surfaces. American Latex Products Corp., Hawthorne, Calif., reports special characteristics include electrical resistance of 1-10 megohms per sq in., optical transparency, water resistance and lack of hazing. Electrical charges are conducted from the plastic or glass areas to the fuselage and discharged by a wick installation or thermal jet discharge.

HEAT RESISTANT PLASTICS ....

. . . . New plastics, made of boron combined with phosphorus or arsenic, that can be heated to 700 F without damage, are predicted by scientists at University of Southern California, Los Angeles, Calif. It is claimed that boron hydride mixed with a hydrogen compound of phosphorus or arsenic produced a low polymer when hydrogen is removed. These can be converted to high polymers that will withstand severe heating without damage to the material.

SILICONE RUBBER ....

. . . . A new compound that is claimed to have a tear strength two to three times higher than similar market compounds has been developed by General Electric Co., Plastics Dept., Decatur, Ill. The elastomer has proven satisfactory as a seal for synthetic base oils at temperatures as high as 375 F. It is also recommended for molded ducts and connectors for hot air lines, particularly where oil mist is present. Flexibility has been maintained over a range of minus 65 to plus 555 Fahrenheit for some installations.

PROCESSES

. . . . Economical methods for producing expanded lightweight aggregates from local materials are being sought by Washington State Institute of Technology, Pullman, Wash. Researchers are exploring clay banks and coal mine dumps for suitable starting materials. Extensive deposits of clay and shale in Washington give promise of providing large quantities of lightweight construction materials if suitable expanding techniques can be developed.

INDUCTION HEATING ....

. . . . Recent improvements in low frequency induction heating have opened new fields of applications in the metalworking industry. Magnethermic Corp., Youngstown, Ohio, reports that it is possible to heat billets uniformly or with axial temperature gradient using a split coil heater. Typical heater for copper and copper base alloys is rated at 1,000 kw and will heat 10,000 lb of metal from 1,300 to 2,100 F in one hr. 6 in. dia steel billets can be heated to 2,300 F in 5 min. 6,000 lb aluminum billets can be heated to extrusion temperature in 35 minutes.

TITANIUM INGOTS ....

. . . . A process for producing titanium-alloy ingots weighing up to 100 lb by means of a double melting process has been worked out by the Armour Research Foundation, Chicago, Ill. The process starts with titanium and alloying material, such as aluminum and silicon, being fed into a non-consumable electrode arc melting furnace. The resulting ingot is forged into a rod, which then is remelted as a consumable electrode to disperse the alloying metals to make a homogeneous alloy.

THIN MAGNESIUM STRIP ....

. . . . For stock of thinner gage than 0.010 in., magnesium becomes too hard and stiff to be rolled by the ordinary hot rolling techniques. The Burgess Battery Co., Freeport, Ill., found that excessive heat loss from the metal and the roll was the cause. By the application of an electric current to the magnesium sheet just prior to the passage of the sheet through the rolls, it was possible to maintain the temperature at the proper value without overheating or excessive grain growth. Magnesium sheet is claimed to have been rolled as thin as 0.001 in. by this method.

BENDING OF TITANIUM STRIP ....

. . . . Markedly improved bending properties can be obtained in titanium strip by removing a thin layer of metal from the surface, either by grinding or pickling. Case Institute of Technology, Cleveland, Ohio, claims that embrittlement results from the absorption of oxygen or nitrogen during annealing or hot rolling and that removal of the surface layer of metal restores the bending properties. In sheet ranging from 0.021 to 0.083 in. thick, removal of a 0.001 in. layer from each side is sufficient. Too much pickling is apt to produce another type of embrittlement, probably caused by the absorption of hydrogen, and should be used with care.

(continued on page 9)

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Highlights ~

COMPONENTS

. . . . A magnet composed of a ceramic material lighter in weight than metal and requiring no critical ingredients is a development of the Indiana Steel Products Co., Valparaiso, Ind. It is reported that the magnetizing force needed is about three times that used for permanent magnets but that it is virtually impossible to demagnetize the unit by ordinary means. Magnet is best suited for uses where application limits magnetic lengths and where magnet may be subjected to high demagnetizing forces. Magnet is to be called Indox.

RESIN TUBE . . . .

. . . . A fluorocarbon resin hose capable of handling the synthetic oils used in jet engines has been developed by Resistoflex Corp., Belleville, N. J. The newer synthetic oils, developed because conventional lubricants would not stand up under temperature extremes of jet operations, meet operational requirements but cannot be carried through the usual fluid carrying materials. The fluorocarbon hose is claimed to solve this problem and can be used for other fluids.

SMALL COMPUTER . . . .

. . . . A sub-miniature analog computer component that has no moving parts but does all the mathematical problems larger units can do, has recently been developed. Arma Corp., Garden City, N. Y., reports that the unit is operated by heat transfer between parts and replaces five times its weight and volume in instruments previously needed. Applications include airborne, land, and sea based equipment, as well as automation of a variety of projects for industry and commerce. Unit is suitable for mass production.

PRESSURE TRANSDUCER . . . .

. . . . A water-cooled pressure transducer can measure dynamic pressures at temperatures above 5,000 F. Control Engineering Corp., Norwood, Conn., which designed the unit, claims that the water jacketing enables it to dissipate 11 Btu per sec per sq in. of exposed area. Exposed parts are made of stainless steel, which permits its use even in highly oxydizing atmospheres and at extremely high temperatures.

NON-METAL DUCT . . . .

. . . . A new non-metal high temperature duct connector has recently passed direct flame tests at 2,000 F for 15 min, combined with high vibrations and flexing. Arrowhead Rubber Co., Downey, Calif., reports that the coupling is fabricated of multiple piles of silicone rubber-impregnated, fiber glass fabrics. Pressure and low temperature tests indicated that the material can withstand 35 psig while at the elevated temperature and will retain flexibility down to minus 125 Fahrenheit with good vibration characteristics.

ATOMIC BATTERY . . . .

. . . . A method of directly converting rays of radioactive atoms into electricity has recently been developed, says the Radio Corporation of America. The battery, it is claimed, is powered by a small quantity of strontium-90, a radioactive isotope obtained as a by-product of atomic reactor operation. Long life is expected from the battery, as the half life of strontium exceeds 25 years. Similar units have been tested

TESTING

. . . . Work being done for the Atomic Energy Commission on brass rods shows that grain size can be determined by ultrasonic tests that are nondestructive. Sylvania Electric Products, Inc., Bayside, N. Y., reports that grain size of fabricated parts were tested on the Sperry Ultrasonic Reflectoscope at frequencies of 2½, 5 and 10 mc, using both the pulse-echo and the continuous transmission techniques. Tests on grain sizes from 0.015 to 0.150 mm indicate: the ratio of wave length to grain size is 10:1 or less; the first back reflection diminished rapidly in height with an increase in grain size; the number of back reflections is reduced as the grain size increases.

RESIDUAL STRESSES . . . .

. . . . Increasing test work in the field of residual stresses in gears is predicted for the future. These stresses are more complex and hence even more important than the relatively simple external load stresses. General Motors Corp. Research Laboratory, reports that heat treating, grinding, machining, cold working, straightening, static or fatigue loading can introduce or alter residual stresses causing premature failure of parts not previously considered.

LUBRICATION RESEARCH . . . .

. . . . New and improved lubricants and greases are possibilities in the next few years. These include hydraulic oils, quenching oils, core oils and turbine oils as well as high temperature greases and all-purpose soap-base greases. Cities Service Research and Development Co., N. Y., believes that cutting oils will be made to prolong tool life, turbine oils will have higher oxidation resistance and rust preventives, and high-temperature, extreme-pressure greases will be improved by investigations and tests now under way.

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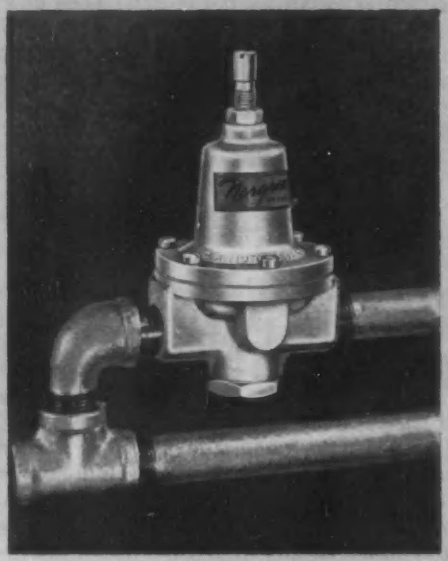

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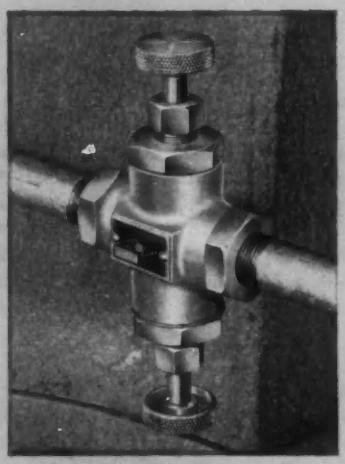

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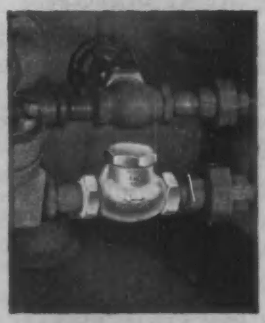

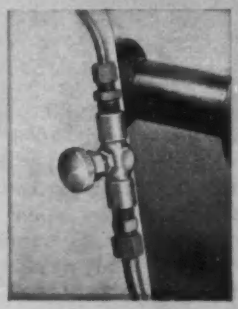

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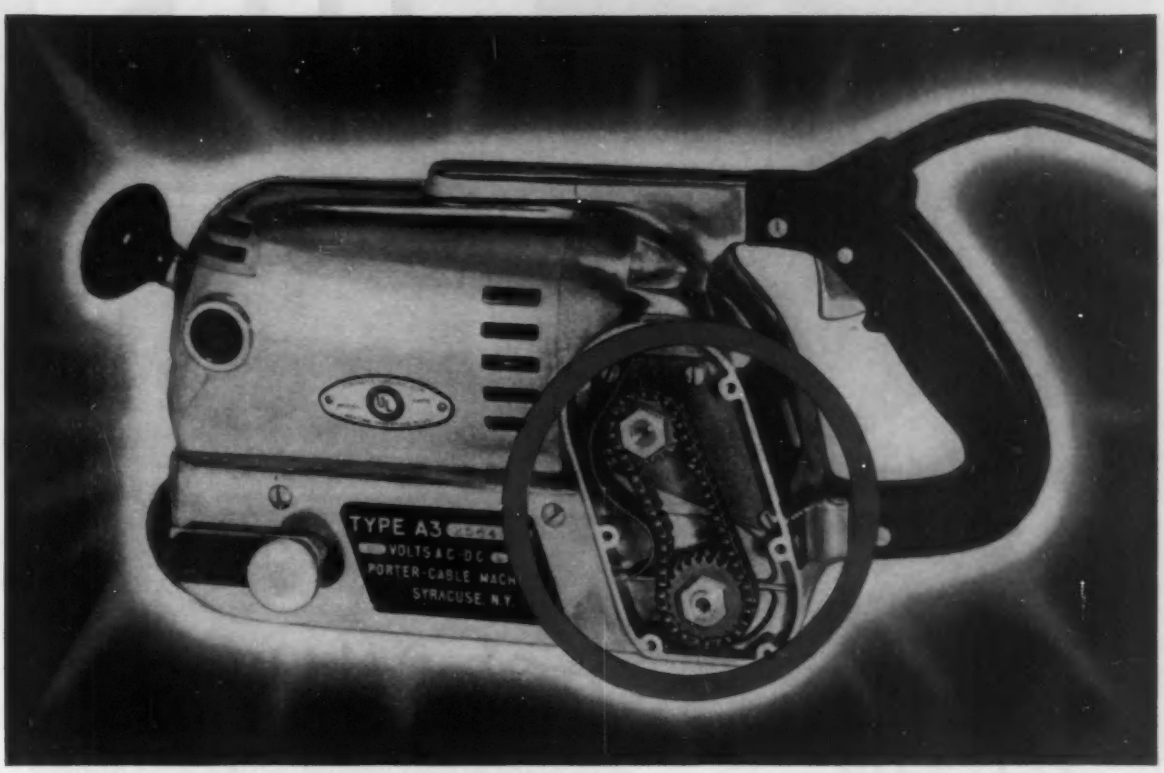
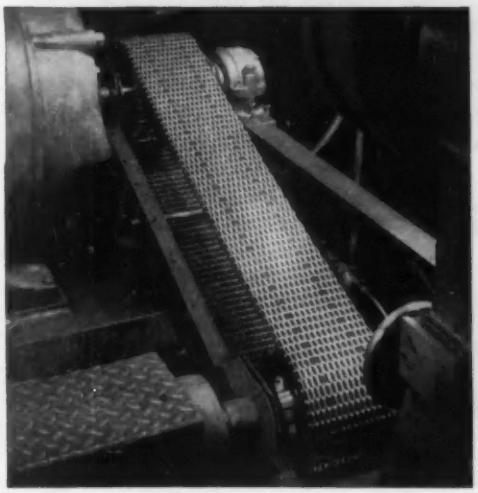
To maintain high efficiency at high speeds

design with LINK-BELT Silent Chain



Portable belt sander is driven with Link-Belt 3/16-in. pitch silent chain. This compact, high-speed chain operates over small wheels, utilizes a spring shoe type tightening mechanism. Its exclusive link and tooth form eliminates chordal disturbance.



Printing "class" magazines calls for precise register of exacting color illustrations at high speeds. As on the majority of the country's high-production presses, Link-Belt Silent Chain provides the drive for this 5-color press that turns out 15,000 impressions per hour.

From fractional to thousands of hp --- your assurance of positive, dependable transmission

SMOOTH, quiet operation is one big reason why so many top designers use so much Silverstreak Silent Chain. Another is the *sustained* efficiency of these positive, no-slip drives—better than 98% throughout their long life. This holds true even at high linear and rotative speeds. And you'll like the flexibility silent chain gives your design. From fractional to thousands of hp, you get space-saving narrow widths . . . long or short center operation . . . ratios up to 10 to 1.

Ask your nearest Link-Belt office for complete design data. Test drives can be quickly supplied.

LINK-BELT

SILVERSTREAK SILENT CHAIN DRIVES

LINK-BELT COMPANY: Plants: Chicago, Indianapolis, Philadelphia, Colmar, Pa., Atlanta, Houston, Minneapolis, San Francisco, Los Angeles, Seattle, Toronto, Springs (South Africa), Sydney (Australia). Sales Offices in Principal Cities. 13,344

DIE CAST OF ZINC

for PHILCO

Here's Why . . . .

Die casting is the only economically feasible means of production for this Philco TV receiver screen frame. And ZINC was the logical choice of metal to obtain the required physical characteristics at the lowest cost. The casting is shown here *as delivered to Philco* with the as-cast surfaces handsomely finished in two-tone durable enamel.

This front view of the ZINC Die Cast frame reveals the unusual contours, the engraved lettering and serrated decorative treatment, and the cored openings in the recessed control panel at the base—all obtained in the high speed casting operation! A rear view of the casting would reveal ingenious coring to insure maximum strength with a minimum amount of metal, plus cast bosses to facilitate assembly of the frame to the cabinet.

Add to the foregoing the dimensional accuracy of ZINC Die Castings and you have the principal reasons for the ever-increasing use of this metal and method of production. For many more examples of successful ZINC Die Casting applications in a wide range of products ask us—or any die casting company—for our booklet "The End Uses of the Zinc Die Castings".

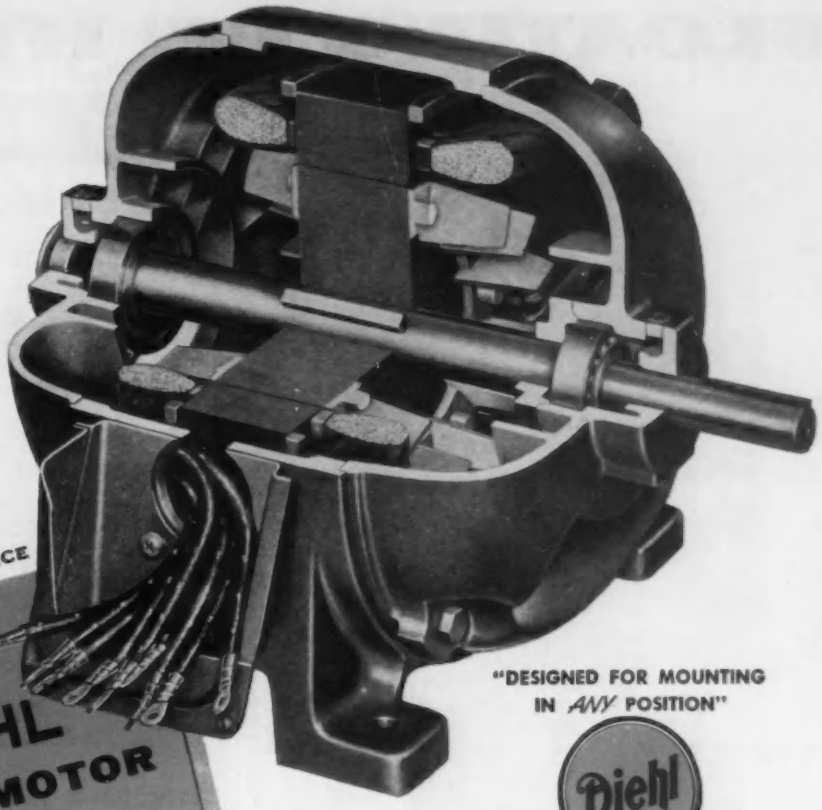
Send for your copy

The New Jersey Zinc Company
160 Front St., New York 38, N. Y.

ZINC
FOR DIE CASTING ALLOYS

The Research was done, the Alloys were developed, and most Die Castings are based on

HORSE HEAD SPECIAL (99.99 + % Uniform Quality) ZINC



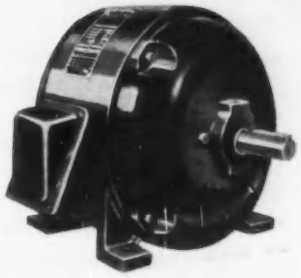
TOPS IN QUALITY
COMPETITIVE IN PRICE

SPECIFY THE New DIEHL TYPE "D" MOTOR

"DESIGNED FOR MOUNTING IN *ANY* POSITION"

Diehl

...here's 12 reasons why



- Most Advanced Slot Insulation
- Machine Fitted Stator
- Rotor Keyed to Shaft
- New High Dielectric Insulated Stator Windings
- Permanently Numbered Leads
- Conduit Box, An Electrician's Delight
- Centrifugally Cast, High Density Rotor Windings
- Rugged Stress-Relieved End-Covers
- New Pre-lubricated Heavy Duty Ball Bearings
- Locked-in Ball Bearing
- Dual Ventilation System
- Extra Strong Cast Iron Frame

Designed and engineered for more efficient performance. Smaller in size, lighter in weight and quieter in operation.

Consult our engineers before writing your specifications and get the benefit of 68 years of experience in the design and manufacture of general and special purpose motors

Diehl motors will still be available in old NEMA Standard frame sizes for interchange and replacement.

DIEHL MANUFACTURING COMPANY
Electrical Division of THE SINGER MANUFACTURING COMPANY
Finderne Plant, SOMERVILLE, N. J.

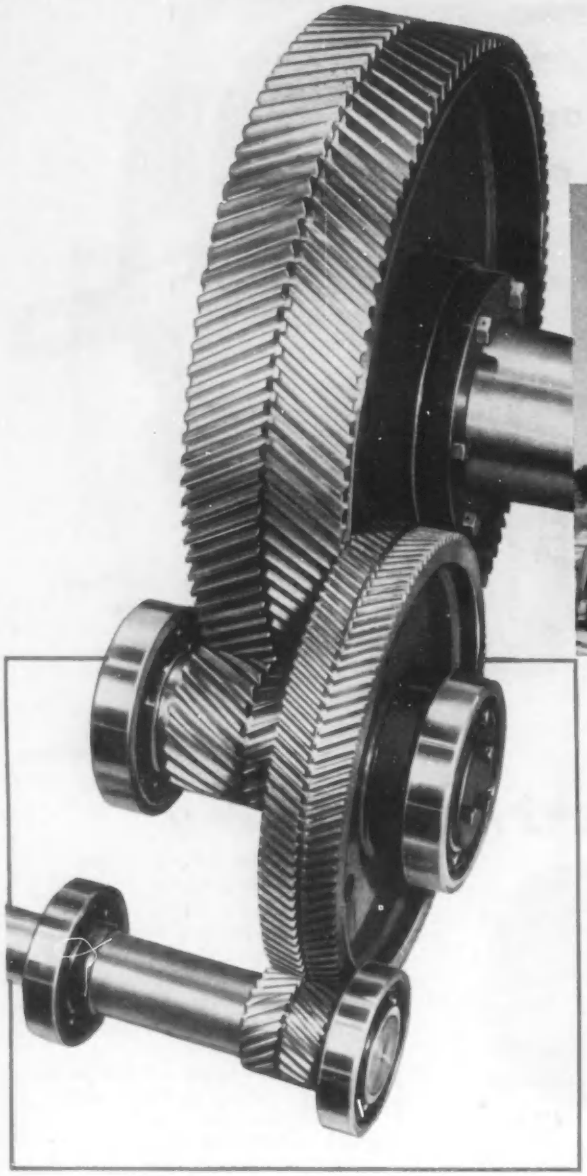
Please send me the following bulletins

☐ New Type "D" Motor Bulletin No. PE 3304
☐ Consolidated Catalog & Price List No. PE 3310

Name_____
Company_____
Street_____
City_____ State_____

INTEGRAL AND FRACTIONAL HORSEPOWER MOTORS ARE AVAILABLE IN A WIDE RANGE OF TYPES AND SIZES

FLOATING ON HYATTS!



This is a job for straight roller bearings, and EMSCO relies on HYATTS!

Take a good look at these herringbone gears—and at the four bearings supporting the two smaller shafts. These particular herringbones operate in the gear box of EMSCO's newest pumping unit, and the bearings are *Hyatt Hy-Loads!* For oilmen, this is a combination that means longer bearing life and lower maintenance costs, because only *straight radial bearings* permit these gears to locate themselves for most efficient operation. And when the application calls for radial-type bearings, EMSCO engineers specify Hyatts. Hyatts offer the proven advantages of easy assembly, simple maintenance, complete interchangeability of parts, and longer life. Insist on Hyatt Hy-Load Bearings for herringbone gear applications.

HYATT ROLLER BEARINGS

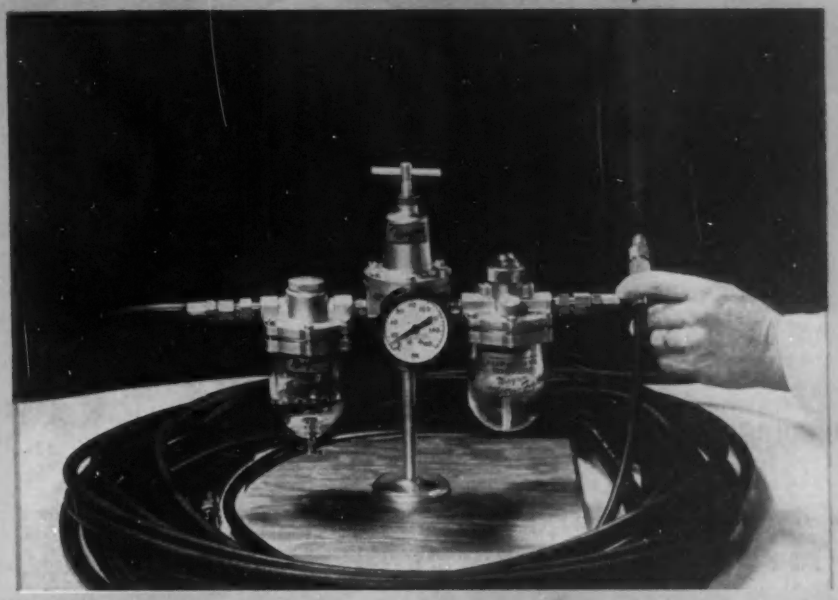
STRAIGHT BARREL TAPER

HYATT BEARINGS DIVISION • GENERAL MOTORS CORPORATION • HARRISON, NEW JERSEY

tests prove

NORGREN MICRO-FOG

delivers lubricating fog after traveling thru 130 ft. of hose



One of the many important advantages of Norgren Micro-Fog is its ability to travel longer distances... a feature which assures absolutely uniform distribution of lubricant through as many as 40 outlets. This reduces lubrication costs and permits greater flexibility in product design and plant layout.

FEATURES OF NORGREN MICRO-FOG LUBRICATORS FOR SMALL AIR-OPERATED DEVICES

VISIBLE OIL FEED CONSTANT OIL LEVEL

Rate of feed is not affected by oil supply.

OIL FEED CONTROLLED BY AIR

Gives accurate control and uniform rate of feed.

WRITE FOR NEW CATALOG No. 600

Vitalizer Unit for tools, cylinders, etc.

Micro-Fog Lubro-Control Unit for bearings, spindles, gear boxes.

Micro-Fog Lubro-Control Unit for tools and cylinders requiring regulated air pressure.

Micro-Fog Lubricator, tank type, 1¾ gal. cap.

PIONEER AND LEADER IN OIL FOG LUBRICATION FOR **26** YEARS

C. A. Norgren CO.

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VALVES – FILTERS – REGULATORS – LUBRICATORS – HOSE ASSEMBLIES

ANNOUNCING THE NEW MAXITORQ "DISC-PAC"

A "DO-IT-YOURSELF" UNIT
FOR BUILDING YOUR OWN CLUTCH

Due to a growing demand for Maxitorq Floating Discs, we now introduce The *MAXITORQ DISC-PAC* . . . a self-contained unit independent of the actuator.

Patented Maxitorq Separator Springs that prevent drag, abrasion, and consequent heating in neutral . . . and the Maxitorq Locking Plate which locks all discs onto body . . . give you the outstanding features that are so highly favored by machine and product designers.

Thus you may build your own clutch or brake from our standard stock Maxitorq parts. The Disc-Pac keys to your shaft and is easily replaced. Units are available in 8-disc diameters from 2″ to 8″; ¼ to 15 h.p. at 100 r.p.m. . . . with 3 lugs on the smallest size, 8 lugs on the 3 h.p., and 12 lugs on the 5, 10 and 15 h.p. capacities.

The Disc-Pac fits Maxitorq standard Driving Rings in the event that you want to use them. As with the Maxitorq Clutch, all assembly, take-apart and adjustments are manual . . . no tools required.

Write Dept. PE-3 for full specifications and quotations.

1CJ84

THE CARLYLE JOHNSON MACHINE COMPANY
MANCHESTER • CONNECTICUT

Ham on Rye or Rye on Hand?

Count BOTH

(and 1,001 Other Items)

with this New Veeder-Root

VARY-TALLY

Multiple-Unit Reset Counter

Knowing how many apple versus lemon pies, for instance, are ordered on a given day . . . or how many cases of what are in the cellar . . . helps a restaurant *count*rol, make plans, make profits. The same goes for a manufacturer or wholesaler seeking tighter inventory control . . . or for any of the following:

- Traffic Engineers
- Schools and Colleges
- Nurserymen and Florists
- State Park and Forest Services
- Laboratories
- Milk Plants and Ice Cream Processors
- Researchers
- Industrial Plants
- Textile Mills
- Inspection and Quality Control
- Jobbers, Wholesalers, Distributors
- Restaurants and Hotels
- Mail and Phone Order Departments
- Laundries and Linen Supply Houses
- Manufacturers of equipment for:
  - Order Control
  - Stock Control
  - Inventory Control
  - Traffic Control
  - Sales and Market Analysis
  - Laboratory Analysis
  - Payroll Preparation
- and What Do You Want to Count?

Arranged compactly on stands in tiers, the Vary-Tally can be supplied in any of 66 combinations, up to 6 banks high and 12 units wide, with a minimum of 2 units wide. Write for news sheet and prices.

"The Name that Counts"

VEEDER-ROOT INC.

HARTFORD 2, CONNECTICUT

Chicago 6, Ill. • New York 19, N. Y. • Greenville, S. C. • Montreal 2, Canada • Dundee, Scotland • Offices and Agents in Principal Cities

The
MEEHANITE CASTING REPORTER

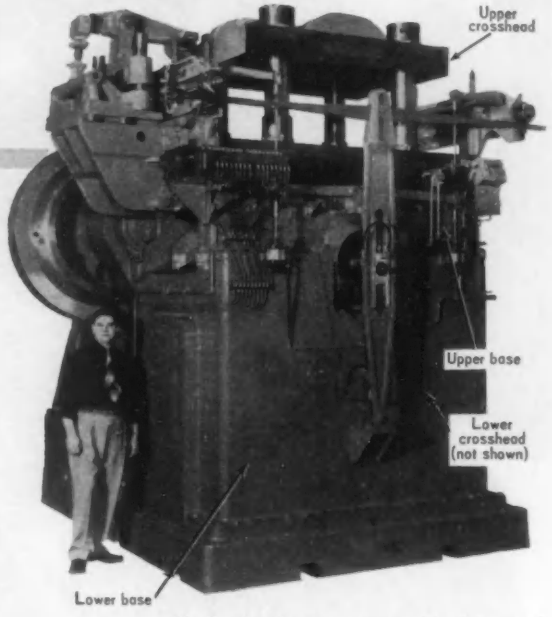
Industry reports what Meehanite Castings have done for them.

PRODUCTION MACHINERY

Maximum Safety Factor —Maximum Strength

Builder Says:

"We have used Meehanite castings ... to obtain close grained uniform castings of maximum strength ... as additional insurance against breaking."



Meehanite Castings as used in Automatic Dieing Machine
Henry & Wright Division
Emhart Mfg. Co., Hartford, Conn.

MACHINE TOOLS

Dimensional Accuracy Through Less Distortion During Hardening

Builder Says:

"With Meehanite castings ... less machining is involved and there is a minimum of distortion during the hardening process."

Broaching Machine
LaPointe Machine Tool Co.
Hudson, Mass.

HEAVY DUTY ROLLS

Increased Bending Capacity at Low Initial Cost

Builder Says:

"In addition to increasing plate bending capacity from 1 inch to 2½ inches the company saved thousands of dollars by designing and casting the rolls of Meehanite metal."

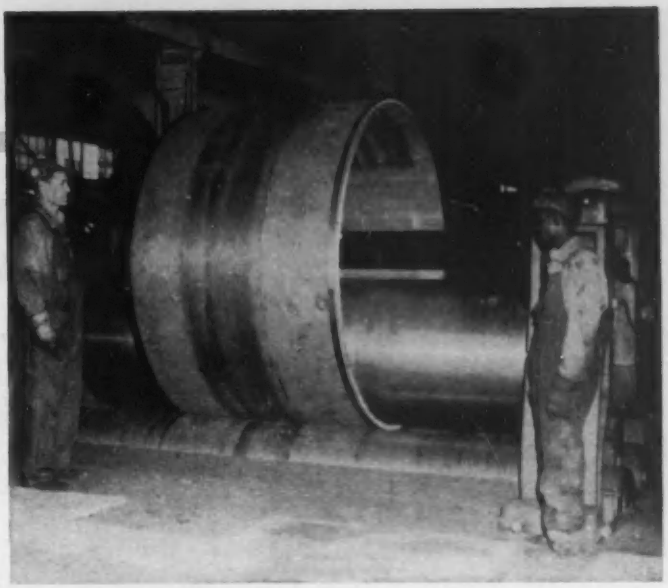


Plate Bending Machine using Meehanite Rolls bends 2¼ inch steel plate. General Iron Works Co., Denver, Colo.

ONLY A MEEHANITE FOUNDRY CAN MAKE MEEHANITE CASTINGS

American Brake Shoe Co. . . . . Mahwah, New Jersey
The American Laundry Machinery Co. . . . Rochester, New York
Atlas Foundry Co. . . . . Detroit, Michigan
Banner Iron Works . . . . . St. Louis, Missouri
Barnett Foundry & Machine Co. . . . Irvington & Dover, New Jersey
E. W. Bliss Co. . . . . Hastings, Mich. and Toledo, O.
Builders Iron Foundry . . . . . Providence, Rhode Island
Compton Foundry . . . . . Compton, Calif.
Continental Gin Co. . . . . Birmingham, Alabama
Crawford & Doherty Foundry Co. . . . . Portland, Oregon
The Cooper-Bessemer Corp. . . Mt. Vernon, Ohio & Grove City, Pa.
DeLaval Steam Turbine Co. . . . . Trenton, New Jersey
M. H. Detrick Co. . . . . Newark, N. J. and Peoria, Ill.
Empire Pattern & Foundry Co. . . . . Tulsa, Oklahoma
Farrel Birmingham Co., Inc. . . . . Ansonia, Connecticut
Florence Pipe Foundry & Machine Co. . . . Florence, New Jersey
Fulton Foundry & Machine Co., Inc. . . . . Cleveland, Ohio
General Foundry & Manufacturing Co. . . . . Flint, Michigan
Georgia Iron Works Co. . . . . Augusta, Ga.
Greenlee Foundry Co. . . . . Chicago, Illinois
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Hardinge Manufacturing Co. . . . . York, Pennsylvania
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Koehring Co. . . . . Milwaukee, Wisconsin
Lincoln Foundry Corp. . . . . Los Angeles, California
Palmyra Foundry Co., Inc. . . . . Palmyra, New Jersey
The Henry Perkins Co. . . . . Bridgewater, Massachusetts
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Ross-Meehan Foundries . . . . . Chattanooga, Tennessee
Shenango-Penn Mold Co. . . . . Dover, Ohio
Sonith Industries, Inc. . . . . Indianapolis, Ind.
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Valley Iron Works, Inc. . . . . St. Paul, Minnesota
Warren Foundry & Pipe Corporation . . Phillipsburg, New Jersey

Canada

Hartley Foundry Division — London Concrete Machinery Co., Ltd., Brantford, Ontario
E. Long Ltd., Orillia, Ontario
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This advertisement sponsored by the above companies.

MEEHANITE®

New Rochelle, N. Y.

MEEHANITE MEANS M METAL BETTER CASTING

Inside this precision lathe by

SHELDON

there's precision power by a

HOOVER

Extra Capacity

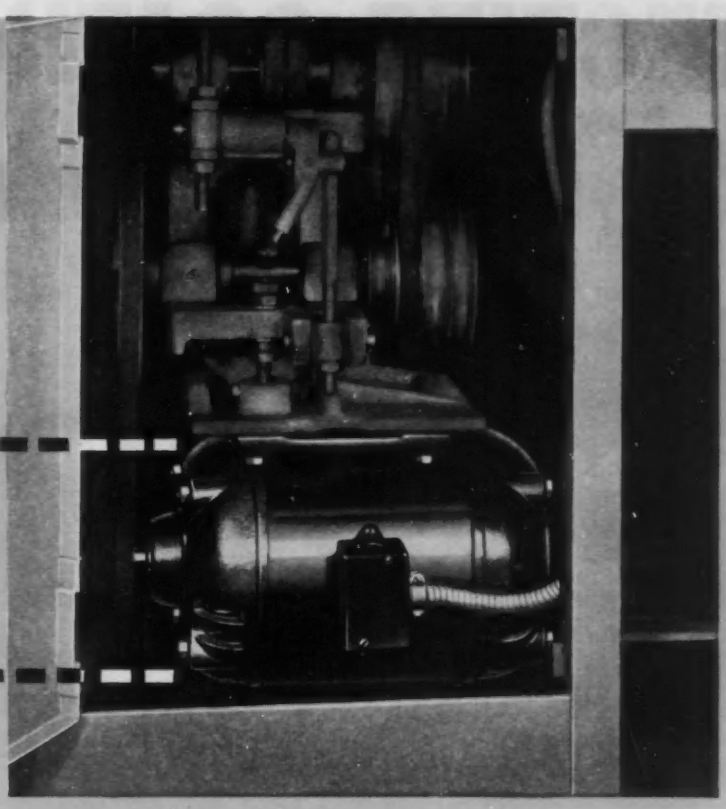
Sheldon Precision Lathes are true double-duty units—with stamina for heavy continuous usage with standard tools at normal speeds and feeds—plus the extra capacity necessary for recently-developed materials and cutting tools operating at much greater power and speeds. Thanks to this flexibility, Sheldon can deliver extreme accuracy on even the most difficult metal-cutting jobs.

Low-Cost Operation

Economical lathe operation depends, to a large degree, on dependable, economical power. Hoover Motors hold down original costs because they provide full-rated horsepower in smallest assembly—and save space in installation. They hold down operating costs because they start freely, run cool, and keep running smoothly. They require little attention, with simplified construction, rugged housing. And Hoover Service Agencies are always nearby to keep outages to a minimum.

Engineered to the Job

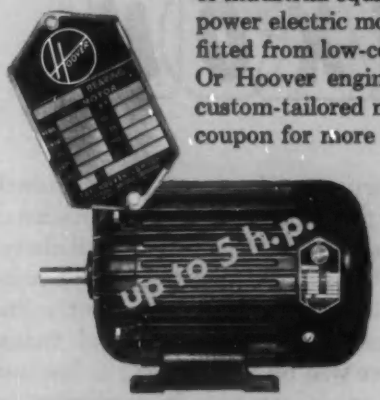
Hoover Motors, too, are engineered to help Sheldon Lathes perform their many jobs. Hoover's been building motors for Sheldon for more than 10 years. Sheldon engineers report Hoover Motors are extremely satisfactory. Sheldon salesmen say they have a good reputation in the field—customers know and trust the Hoover name. And Sheldon users find these motors give trouble-free operation—if trouble ever does strike, the local Hoover Service Agency gives quick adjustment or repairs.



A specially-designed one-horsepower Hoover motor, operating at 1725 r.p.m. powers many Sheldon TS-56B Precision Lathes in shops from coast to coast.

MOTOR

Check with Hoover before you specify the power plant for any domestic or industrial equipment. Hoover supplies a fractional or integral horsepower electric motor for any need, up to 5 h.p. Dozens of applications fitted from low-cost in-production models, available on quick delivery. Or Hoover engineers will work with your engineers in developing a custom-tailored motor to suit your individual requirements. Send this coupon for more details.



PRODUCTION FOR HOME AND DEFENSE
Week in and week out, Hoover is producing a very substantial volume of essential materials for the Armed Forces.

THE HOOVER COMPANY, ELECTRIC MOTOR DIVISION
88 BROOK AVENUE, NORTH PLAINFIELD, N. J.

Please send me further information on Hoover Motors. I am particularly interested in motors for

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(Indicate type of equipment)

Name_____

Company_____

Address_____

City_____ Zone_____ State_____

PROTECTIVE COATINGS with outstanding

Firestone EXON 470

combines the properties of many resins!

- EXCELLENT SOLUBILITY IN METHYL ETHYL KETONE
- HIGH DEGREE OF SOLUBILITY IN AROMATIC HYDROCARBONS
- ADHESION TO METALS
- ADHESION TO ALKYD SURFACES
- ALKYD COMPATABILITY
- ADHESION TO VINYL SURFACES
- EXCELLENT PIGMENT DISPERSION PROPERTIES

Newest addition to Firestone's family of resins is EXON 470... Its possibilities and opportunities for protective coatings have been developed by exhaustive research.

It combines the best properties of many resins used in this field—giving you greater-than-ever efficiency and economy of production. It helps you deliver a better-performing product through the use of one rather than a combination of several resins that protective coatings previously required.

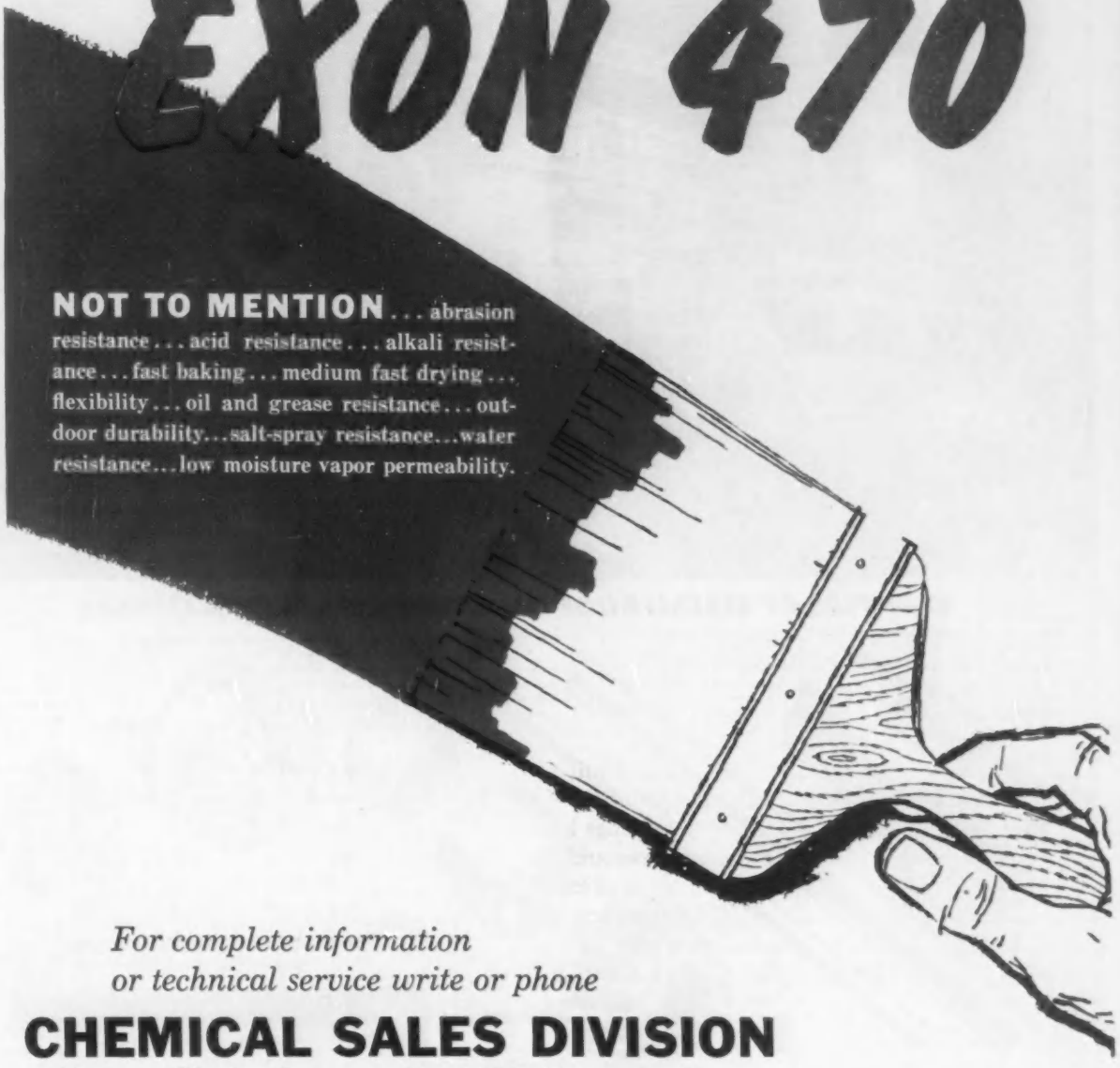
Review the unprecedented combination of properties EXON 470 provides listed above.

From Firestone's laboratories have come a succession of new and important resins for innumerable applications and industries. More will be announced . . . because Firestone resin research is producing an ever-growing EXON line, bringing industry shorter cuts to finer products.

get a brand NEW resin solution characteristics!

Firestone EXON 470

NOT TO MENTION . . . abrasion resistance . . . acid resistance . . . alkali resistance . . . fast baking . . . medium fast drying . . . flexibility . . . oil and grease resistance . . . outdoor durability . . . salt-spray resistance . . . water resistance . . . low moisture vapor permeability.

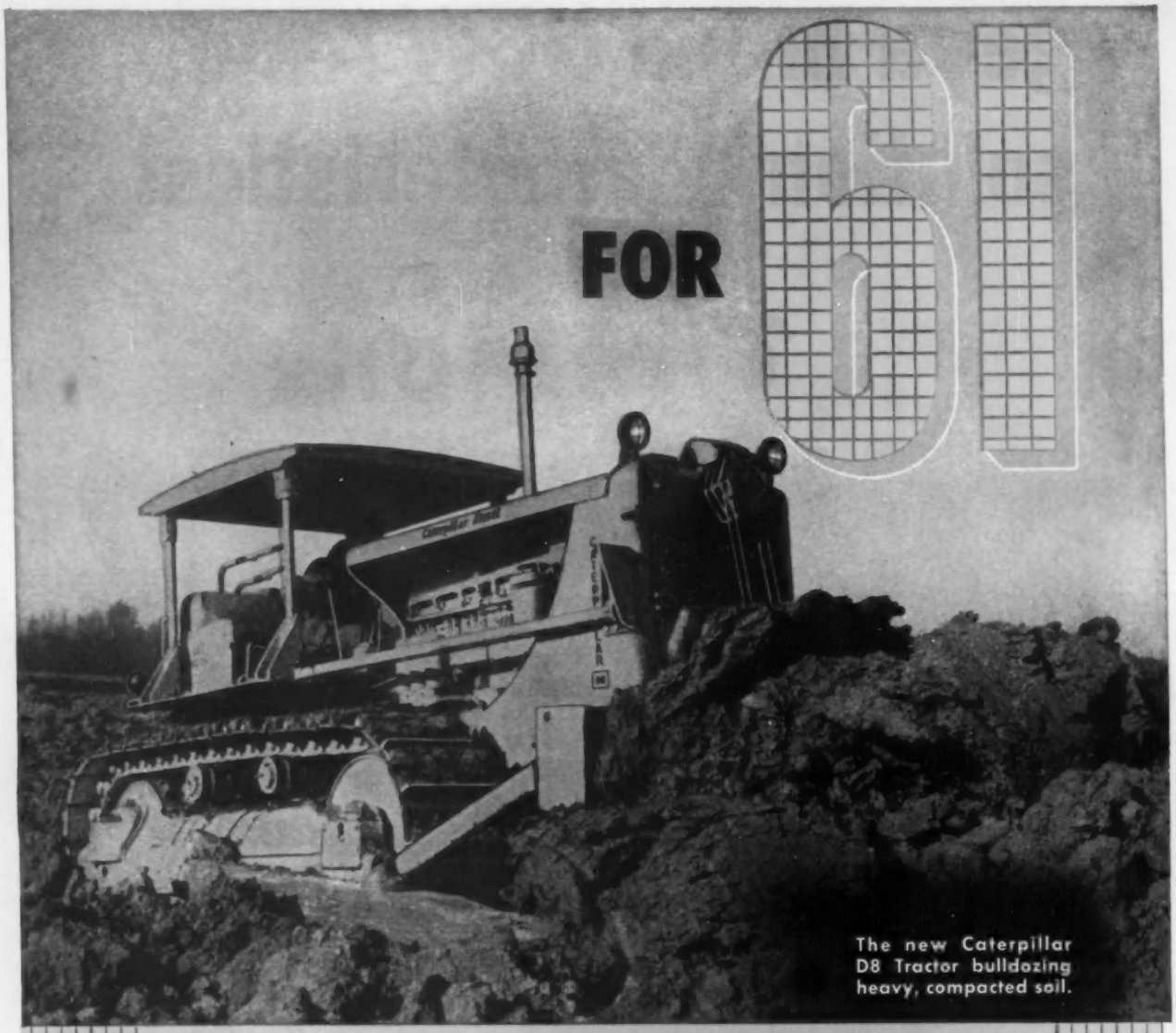


For complete information or technical service write or phone

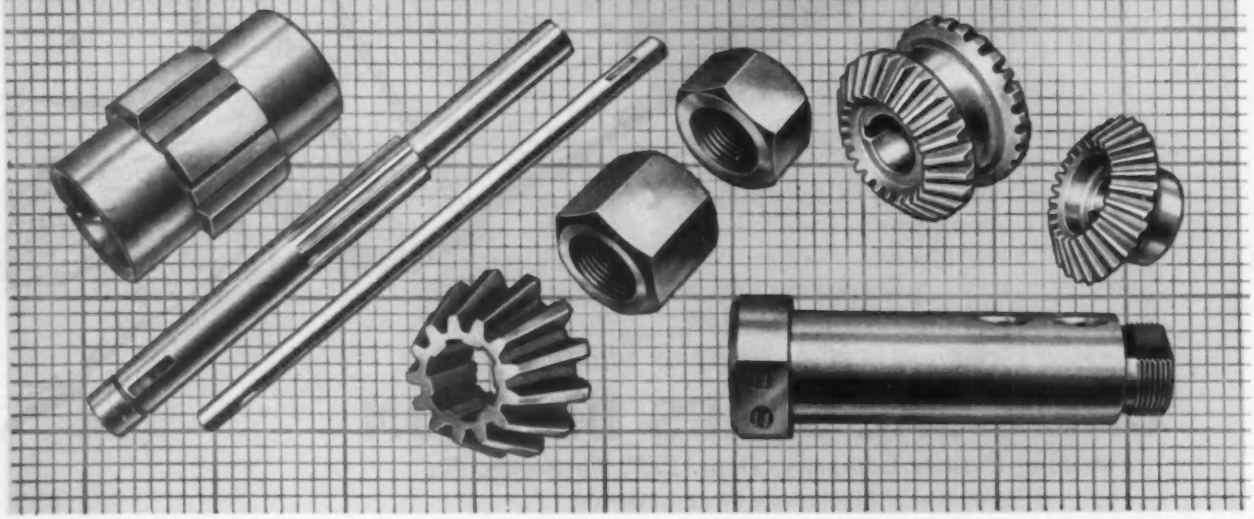
CHEMICAL SALES DIVISION

Firestone Plastics Company, Dept. 22P, Pottstown, Pa.

Division of The Firestone Tire & Rubber Co.



EXAMPLES OF STRESSPROOF ON CATERPILLAR-built MACHINES



IMPORTANT

PARTS

plus many more

purchased from vendors

Caterpillar® Tractor Co. uses

STRESSPROOF®

SEVERELY COLD-WORKED, FURNACE-TREATED STEEL BARS

Caterpillar never compromises quality. A Caterpillar-built machine is known the world over for its strength, ruggedness, and built-in stamina . . . it just doesn't quit.

And Caterpillar uses STRESSPROOF for 61 important parts. STRESSPROOF has the strength Caterpillar wants, the quality they demand, and gives them these qualities as machined . . . without conventional heat treating for these applications.

No heat-treatment of STRESSPROOF is required by Caterpillar—no distortion and cleanup after heat treating—no looking for quench cracks.

In addition, LaSalle STRESSPROOF also provides machinability and finish approaching that of screw stock, affording opportunities for cost reduction.

STRESSPROOF must meet Caterpillar's quality specifications—specifications that give Caterpillar a better part for these applications. Why don't you try this steel on your quality applications? Call or write, today.

SEND FOR . . .

Free Engineering Bulletin
"New Economies in the Use of Steel Bars"

La Salle STEEL CO.

Manufacturers of the Most Complete Line of Carbon and Alloy Cold-Finished and Ground and Polished Steel Bars in America.

La Salle Steel Co.
1430 150th Street
Hammond, Indiana

Please send me your STRESSPROOF Bulletin.

Name _____

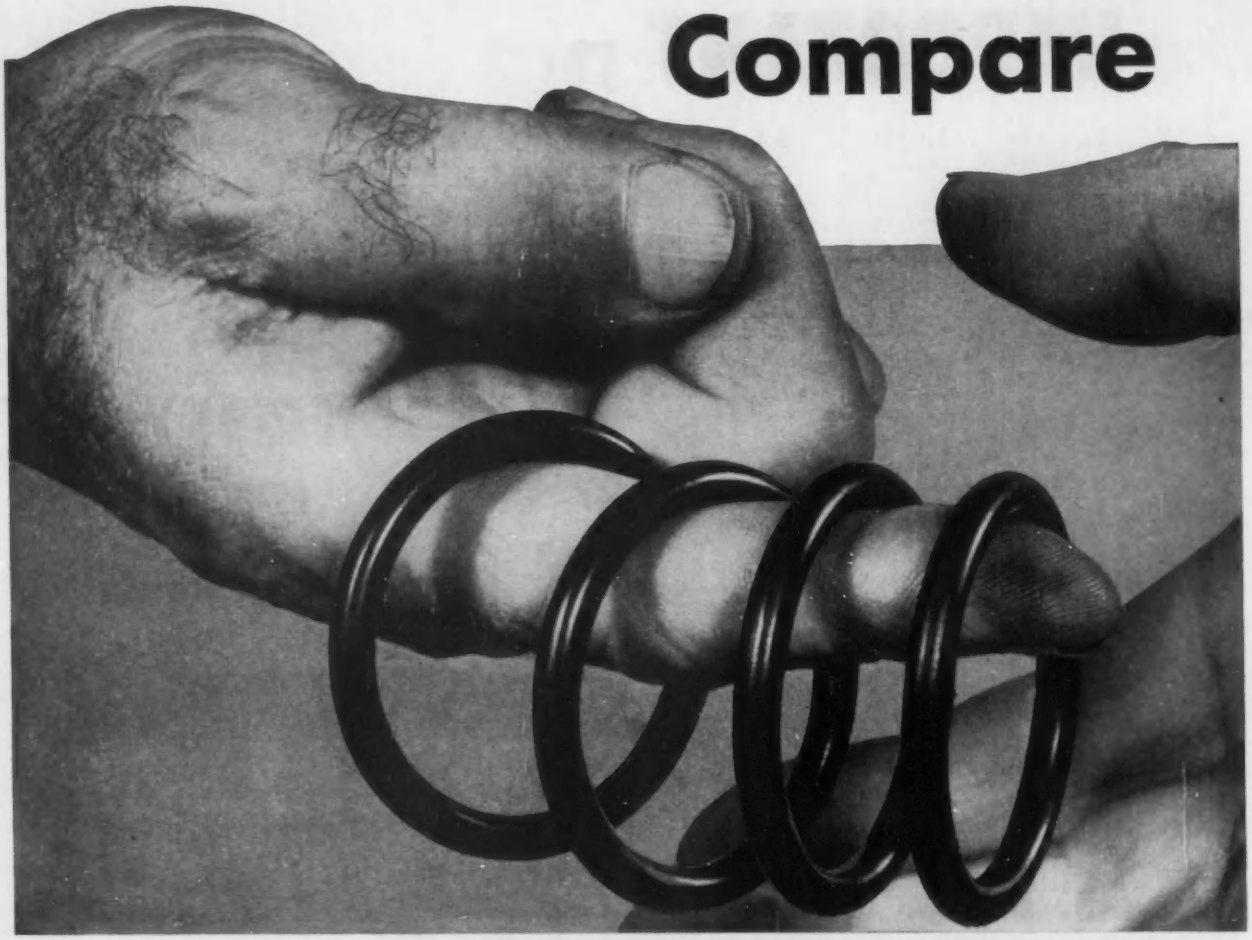
Title _____

Company _____

Address _____

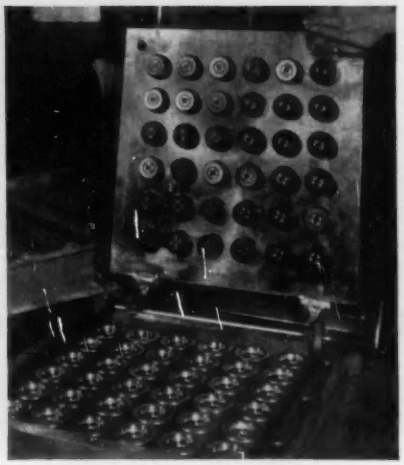
City _____ Zone _____ State _____

Compare



2. Laboratory and service tests of Parker compounds determine tensile strength and maximum compression set; then make sure these rated characteristics are held.

3. Fluid and temperature tests check compound resistance to oils, fuels and chemicals at high and low temperatures . . . assuring the long life of Parker O-rings.



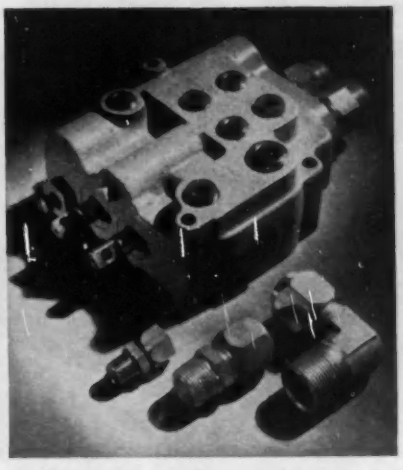
4. Precision molding by exclusive, automatically controlled methods assures close-tolerance fits. Parker has molds for *every* standard O-ring size.

actual O-ring samples

Prove by comparison tests how Parker O-rings seal better and last longer

1. For trouble-free, leakproof sealing, you can depend on Parker O-rings. They are precision molded of superior compounds that have been developed as the result of thousands of tests. When you ask about Parker O-rings, we check your specifications to determine which of our O-rings is exactly *right* for your *specific* application. Then, we invite you to make your own comparison tests of Parker O-rings with any other make. Here are some of the reasons why you'll find that Parker O-rings seal better and last longer:

5. Get complete data in Catalog No. 5100. Ask your Parker representative or mail the coupon for a copy. Then, compare actual sample O-rings.



6. What other Parker products for *hydraulic* and *fluid* systems interest you? Triple-lok flare fittings? *Ferulok* flareless fittings? New directional control valves? Any others?

THE PARKER APPLIANCE COMPANY
Section 504-L
17325 Euclid Avenue
Cleveland 12, Ohio

Please send me the following information:

- ☐ O-ring catalog No. 5100
- ☐ Custom-molded rubber catalog No. 5201A1
- ☐ Information about these other specific Parker products_____

NAME_____ TITLE_____

COMPANY_____

ADDRESS_____

CITY_____ STATE_____

RUBBER PRODUCTS DIVISION
The Parker Appliance Company
17325 Euclid Ave., Cleveland 12, Ohio
1538 South Eastern Ave., Los Angeles, Cal.

Parker
Hydraulic and fluid system components

YOU GET eleven CONTACT ARRANGEMENTS IN one

80 DEGREES OVERTRAVEL

11 CONTACT ARRANGEMENTS

SIMPLE ADJUSTMENT

OIL TIGHT

EASY STOCKING

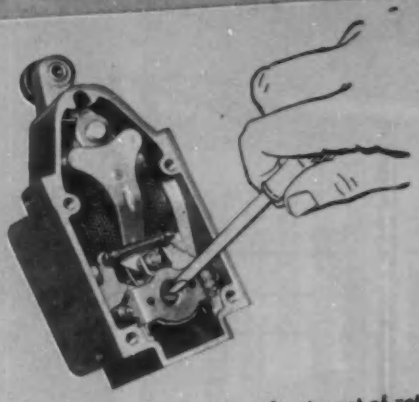
EASY MOUNTING

RUGGED MECHANISM

Write for Bulletin SM-239
Address Square D Company,
4041 North Richards Street,
Milwaukee 12, Wisconsin

SQUARE D COMPANY

WITH THIS NEW MACHINE TOOL LIMIT SWITCH!

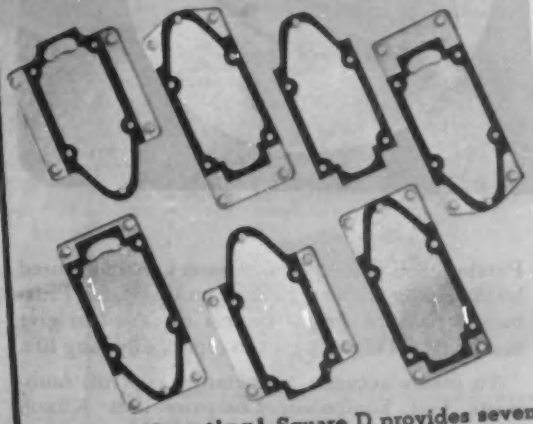


Versatility Plus! Simple adjustment of return spring positioning plate determines position of the movable contact in the "free" position. Equally simple adjustment of latches makes switch either single acting, or double acting with neutral position . . .

11 switches in 1 . . . all you need is a screw driver!

Adjustable! Operating lever arm position is continuously adjustable and provides up to 80° overtravel unless limited by enclosure. An outstanding Square D design feature.

No Inventory Problem! Square D's basic switches and lever arms are separately packaged for your stocking convenience. A moderate stock covers a multitude of possible combinations.



Easy Mounting! Square D provides seven different base plates, plus side mounting holes. It's easy to mount switches in a variety of positions.

ASK YOUR ELECTRICAL DISTRIBUTOR FOR SQUARE D PRODUCTS

PITTSBURGH GAS FIRED UNITS

obtain Accurate, Dependable Temperature Control

WITH

KLIXON *Thermo Snap* CONTROLS

Pittsburgh Gas Fired Unit Heaters, manufactured by the Automatic Gas Equipment Company, Pittsburgh, Pa., are quality heaters designed to give maximum BTU value plus exceptionally long life.

To insure accurate temperature control, Automatic Gas Equipment Company uses Klixon Thermo-Snap Controls in their units.

Here's what Mr. N. L. Blackmore, Sales Manager, has to say about Klixon Thermo-Snap Controls:

"The small limit control, your C-4370, which we use is compact and takes up little space and does a very good job.

We have been using Klixon Controls for over fifteen years and have found them to be very durable and dependable."

What's your temperature problem . . . low and high limit controls, fuel delay switches, tube and rectifier cooling, fan switches, temperature control . . . Klixon Thermo-Snap Controls are meeting the requirements for these and other applications in military and civilian products, daily.

Klixon Thermo-Snap Controls are available in many hermetically sealed and open types in a wide variety of operating temperature ranges.

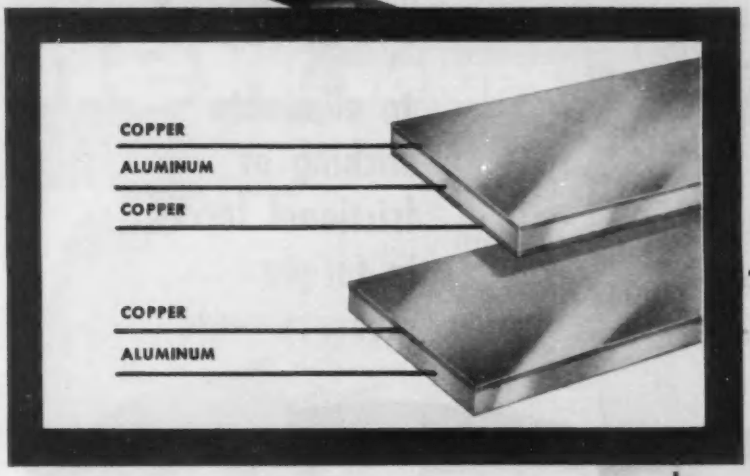
Klixon Engineers, specialists in temperature control applications, can help you solve your specific problems. Write for their help or further information.

KLIXON

METALS & CONTROLS CORPORATION
SPENCER THERMOSTAT DIVISION
903 FOREST STREET, ATTLEBORO, MASS.

GENERAL PLATE
ALCUPLATE®
(COPPER ON ALUMINUM)

Cut Costs 15 to 30%



ALCUPLATE Plus Features

- High Electrical Conductivity
- Excellent Heat Dissipation
- Soft-Soldering Surfaces
- Easy Fabrication
- Light Weight

Manufacturers of various products are reducing costs by 15 to 30% or more over an equal area of copper or brass with General Plate ALCUPLATE... Copper clad on one or both sides of aluminum.

Here's how ALCUPLATE saves — by permanently bonding a thin layer of copper to thicker less expensive aluminum. You get solid copper performance at a lower cost over solid copper. This combination has practically the same physical and electrical properties as copper plus the light weight of aluminum.

ALCUPLATE can be fabricated by stamping, drawing, spinning, and forming. Its malleability permits its use in the manufacture of many parts from work-hardened rather than annealed or dead soft materials.

ALCUPLATE is available in coils and flat cut lengths, copper clad on one or both sides of aluminum, 1/16" thick x 13" wide and under.

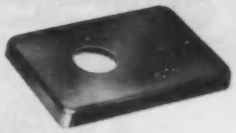
Technical Data Bulletin No. 702C gives full details. Write for a copy today.

You can profit by using General Plate Composite Metals!

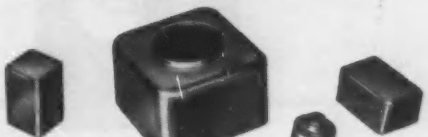
METALS & CONTROLS CORPORATION
GENERAL PLATE DIVISION
13 FOREST STREET, ATTLEBORO, MASS.

A Few of the Many Products Made from General Plate ALCUPLATE

HEAT TRANSFER UNITS — ALCUPLATE provides ideal fin sections at reduced cost over solid copper fins. The copper surface permits soft soldering of the fins to the tubes.



ELECTRONIC CHASSIS — Minimum weight combined with copper surface required for soft-soldering operations, electroplating, and low-resistance shield connections are advantages obtained by using ALCUPLATE.



COMPONENT CASES — ALCUPLATE is successfully drawn and formed into lightweight cases or cans and intricate parts.

BUS BARS — ALCUPLATE provides high conductivity, light weight, solderability... and is lower in cost than solid copper bus bars.

ELECTRICAL TERMINALS — Small terminals and large pressure-type connectors use single-clad ALCUPLATE... alleviates galvanic corrosion which otherwise results from aluminum and copper junctions.

the Link Uni-Beam uses the smooth . . . . .

HEIM *Unibal* rod end

to eliminate sticking or frictional forces in torque measurements

In the Heim Unibal Rod End, a single ball oscillates in bronze bearing races giving longer life and smoother operation . . . They correct misalignment in every direction because of the universal motion of the single ball. They carry maximum radial and thrust loads, and are more economical than specially machined parts.

The Link Uni-Beam is an instrument used for torque measurement. The Heim Unibal Rod End is used in the oil dash-pot assembly (used as a damping device) because it eliminates any sticking of the damper and allows the torque of a dynamometer to be measured accurately.

THE HEIM COMPANY
FAIRFIELD, CONNECTICUT

Write for complete catalog and sample of Heim Unibal Bearings and Rod Ends.

A-4284

• Greater Protection Against Foreign Matter • Long-Life Bearings • Many Tried and Proven Features

OPEN DRIP-PROOF

Here are a few of the reasons why the new Allis-Chalmers open—drip-proof motor in NEMA rerate sizes gives you better performance, lower maintenance costs in general-purpose applications.

- Better protection against falling water and debris because cooling air inlets are on bottom.
- Long bearing life because large grease chambers provide plenty of reserve lubricant and are thoroughly sealed against foreign matter.
- Quieter operation, smoother performance.

GET COMPLETE INFORMATION

Allis-Chalmers, Milwaukee 1, Wis.

Send for these bulletins:

- ☐ Open — Drip-Proof, Type G, 51B6210
- ☐ TEFC, Type GZ, 51B7225
- ☐ Explosion-Proof, Type GZZ, 51B7286

Name.....

Company.....

Position.....

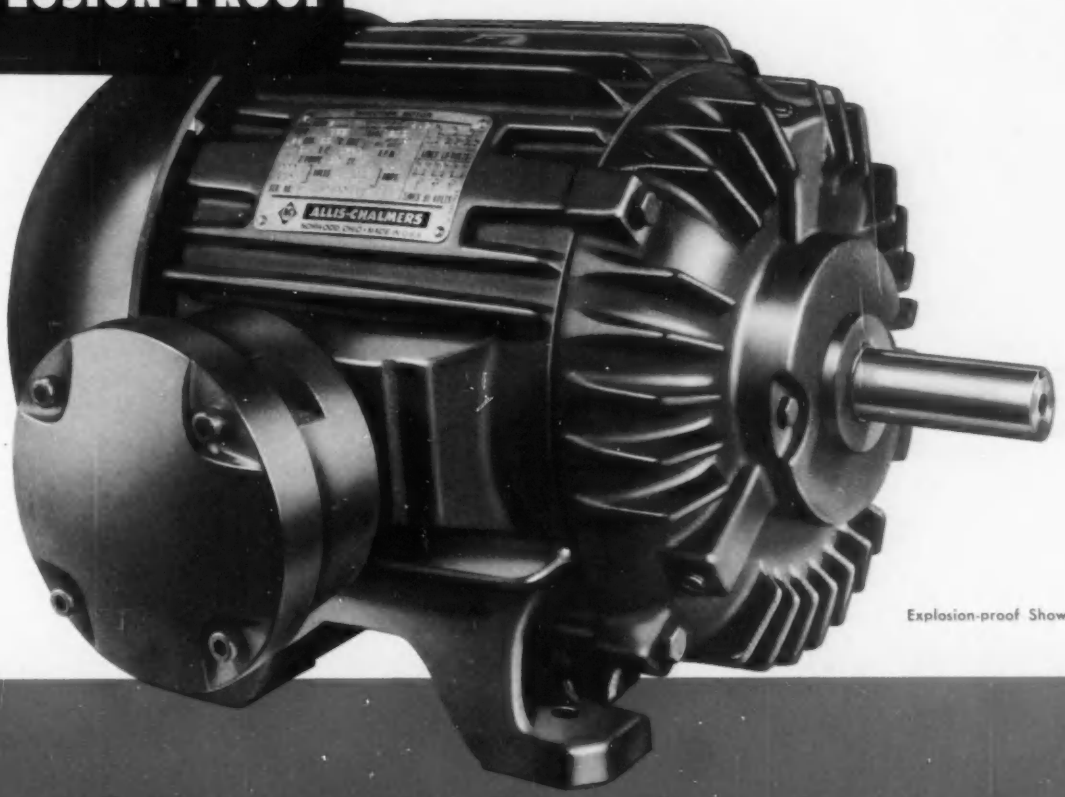
Address.....

City and State.....

A-4284

ALLIS-

TEFC and EXPLOSION-PROOF



Explosion-proof Shown

For especially dirty, corrosive or hazardous applications, you will get top performance with low maintenance costs from the new Allis-Chalmers totally-enclosed, fan-cooled and explosion-proof motors in NEMA rerate sizes. Here are a few of the reasons why—

- Foreign matter kept out of bearings and motor interior by double labyrinth seals inside and outside of bearings, and long running fits between shaft and seals.
- Bearing maintenance reduced because large grease chambers provide space for reserve lubricant; also, if required, grease may be renewed without dismantling.
- Easy to clean — no inaccessible air passages. Dirt wipes or blows off easily.

CHALMERS

A-C ALLIS-CHALMERS

Everything you need . . .

from Line to Shaft

Motor, Control, *Texrope* V-belt Drive . . . All from one reliable source

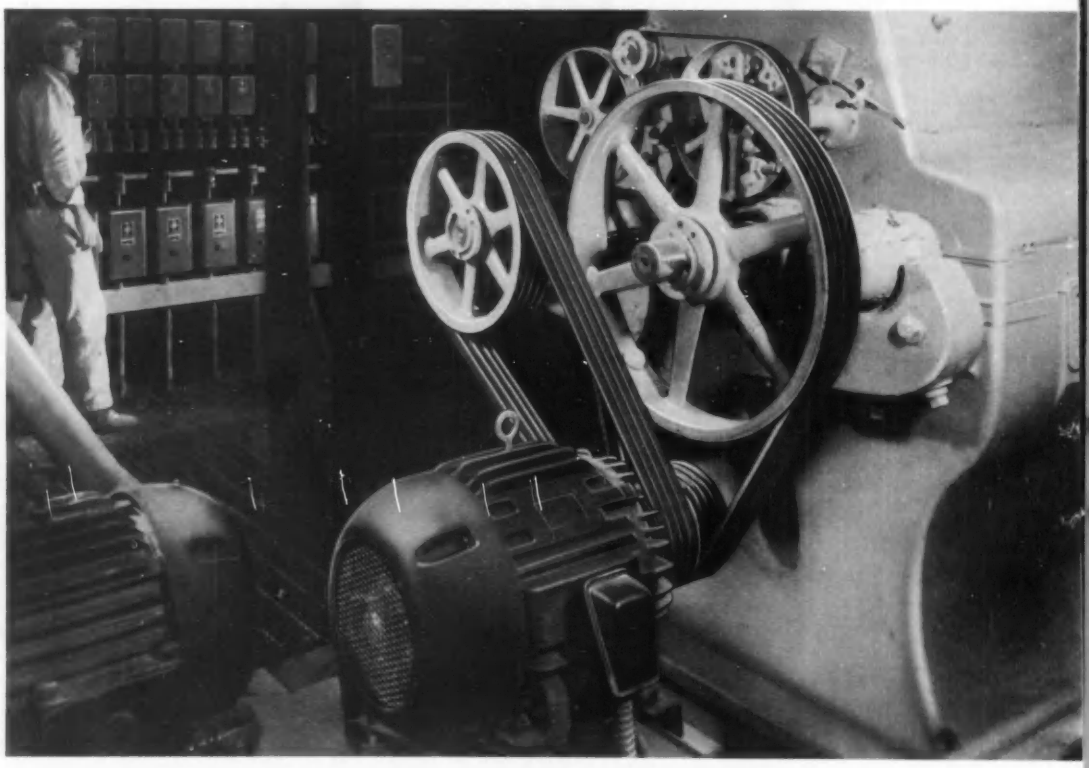
You will save time and engineering costs and reduce assembly problems when you use an Allis-Chalmers complete machine drive. Components are of coordinated design and manufacture. Ratings coincide and parts fit and work together properly when assembled. One requisition, one order, one invoice saves on paperwork. And you can obtain engineering assistance from qualified field application engineers who thoroughly understand the complete drive problem.

NATION-WIDE CERTIFIED SERVICE

Almost a hundred Allis-Chalmers Certified Service Shops in industrial areas in all parts of the country provide factory-approved service and parts. If you use a special motor, Certified Service Shops have the full benefit of factory drawings and advice for service work.

Call the Allis-Chalmers District Office near you next time you have a drive problem. A competent application engineer will be glad to put the full facilities of Allis-Chalmers at your disposal.

Texrope is an Allis-Chalmers trademark.



ALLIS-CHALMERS

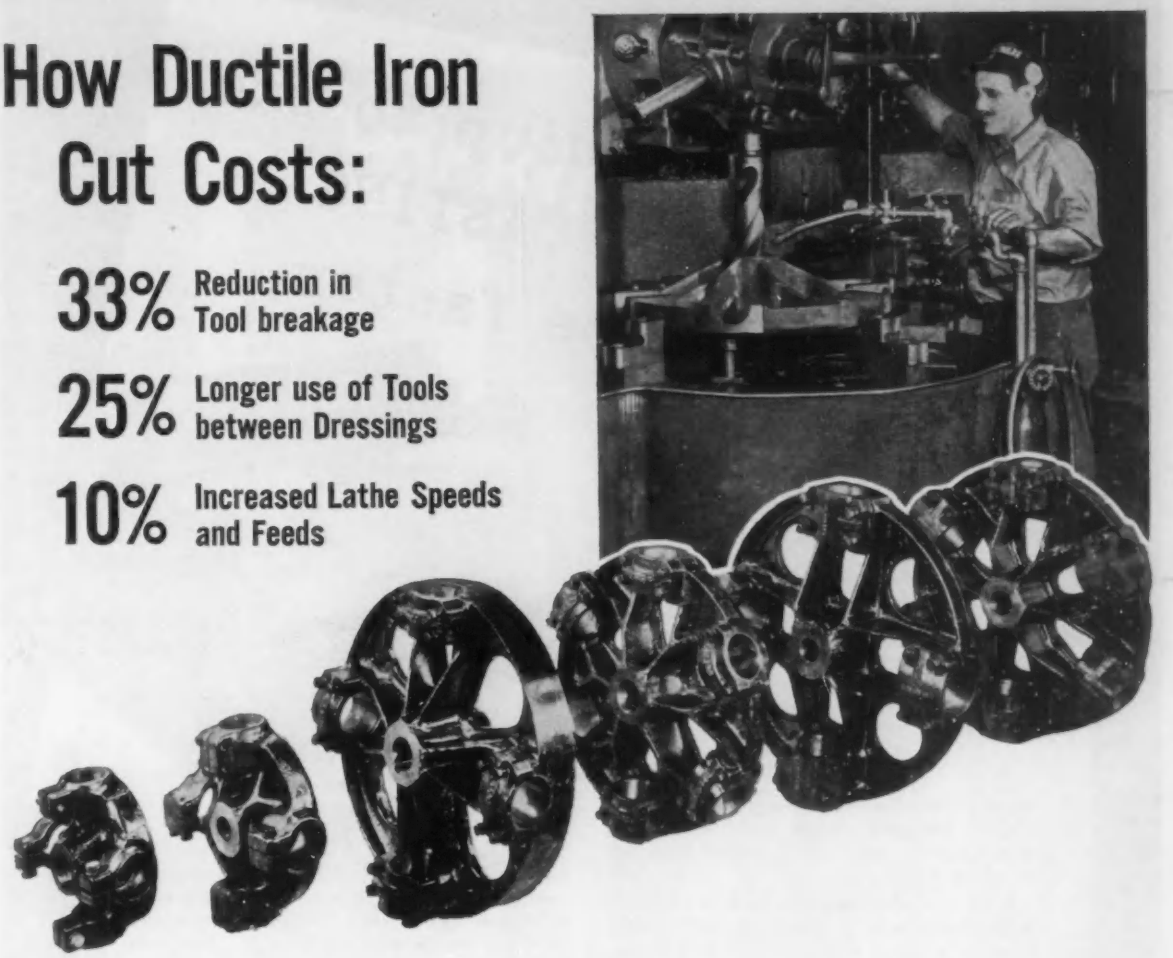
Milwaukee 1, Wisconsin

How Ductile Iron Cut Costs:

33% Reduction in Tool breakage

25% Longer use of Tools between Dressings

10% Increased Lathe Speeds and Feeds



Who will be next to make better products for less money by using Ductile Iron?

Profit from the example of Metal Products Division of Koppers Company, Inc., Baltimore 3, Md. This manufacturer not only cut costs but improved performance of one of their specialties by adopting Ductile Iron hubs for "Aeromaster" industrial fans.

These propeller-type fans, ranging from 54 inches to 24 feet in diameter, are generally used in pipeline pumping stations and similar places where vibrations from nearby engines, compressors or other machinery compound the vibrations of a fan.

INCO

For the hubs, which may vary from 50 to 225 pounds in weight, good tensile and fatigue properties are obviously essential. In addition, excellent castability is needed because the heavy center portion, the heavy flange and the thin inter-connecting webs of each hub vary considerably in section thickness.

So far, no Ductile Iron hub has been rejected. The manufacturer sand-blasts hub castings and then heat-treats to provide 60,000 p.s.i. minimum tensile strength and 15% elongation.

Tensile strengths in excess of 150,000 p.s.i. may be attained by other heat-treatments. Investigate how Ductile Iron can improve your products or equipment. Learn the facts about its machinability, its resistance to wear, to shock and vibration. Investigate the facts about its damping capacity.

Send us details of your prospective uses, so that we may offer a list of sources from some 100 authorized foundries now producing Ductile Iron under patent licenses. Request a list of available publications on Ductile Iron... mail the coupon now.

The International Nickel Company, Inc.
Dept. 20, 67 Wall Street,
New York 5, N. Y.

Please send me a list of publications on: DUCTILE IRON.

Name_____

Title_____

Company_____

Address_____

City_____ State_____

THE INTERNATIONAL NICKEL COMPANY, INC. 67 WALL STREET NEW YORK 5, N. Y.

"from qwertyuiop to zxc vbnm,./- DIE CASTING helps me type faster, better and longer" . . .

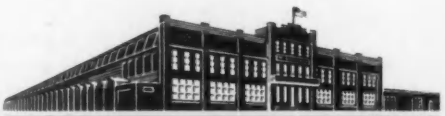
CASE HISTORIES FROM MT. VERNON FILES

The new Smith-Corona "Eighty-Eight" is really a beauty. "Designed and built to out-perform any office typewriter ever made" is what its makers say about it.

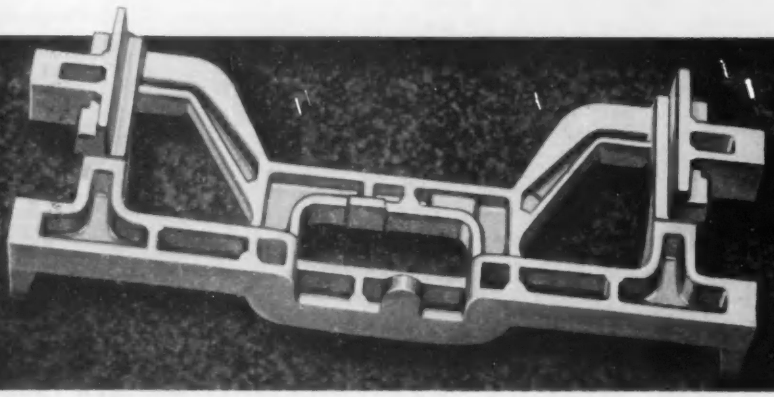
And this is what they also have to say about the Mt. Vernon die casting shown below, which forms an essential part of the "Eighty-Eight.":

"This particular casting was designed for maximum torsional, compressive, and tensile strength. In an analogy of the automobile industry, this casting might be called the 'engine mounting' of a typewriter; the engine of the typewriter being the typebar segment. Because of the high strength characteristics needed for an 'engine mounting', we selected die cast aluminum. Other reasons for selecting die casting are its high degree of accuracy in contour and the lower cost of machining processes."

Whatever your product, whether simple or intricate, consult with us. We have up-to-the-minute facilities for die casting aluminum and zinc, and a vast reservoir of experience in die making. It's highly possible that we can help you, as we helped Smith-Corona, to lower unit costs . . . show you the way to improved products, too.



MT. VERNON
DIE CASTING CORP.
STAMFORD, CONNECTICUT



TO CUT "CARRYING" CHARGES...

TABLE TOP CHAIN

ROLLER CHAIN AND ATTACHMENTS

CHABELCO® CHAIN AND ATTACHMENTS

STEEL DETACHABLE CHAIN AND ATTACHMENTS

FLEXIBLE COUPLINGS AND SELF-ALIGNING ROLLER BEARINGS

For any cost-reduction or product-improvement program that involves the movement of material through a machine, there is a size and type of Chain Belt Chain and Attachment that can help you. From the complete line, your Chain Belt District Sales Engineer will be happy to assist you in your drive or conveyor chain, sprockets, flexible couplings and self-aligning roller bearing selections. He has a broad background of experience in conveying and power transmission . . . can help you cut your "carrying" charges! Call your Chain Belt Sales Engineer or mail the coupon today.

Always the one best chain for each service

CHAIN BELT COMPANY

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I am designing a.....

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.....

☐ Send literature on: ☐ TableTop; ☐ Roller Chains; ☐ Chabelco Chains; ☐ Detachable Chains; ☐ Couplings; ☐ Bearings; ☐ Sprockets.
☐ Have my Chain Belt Man call.

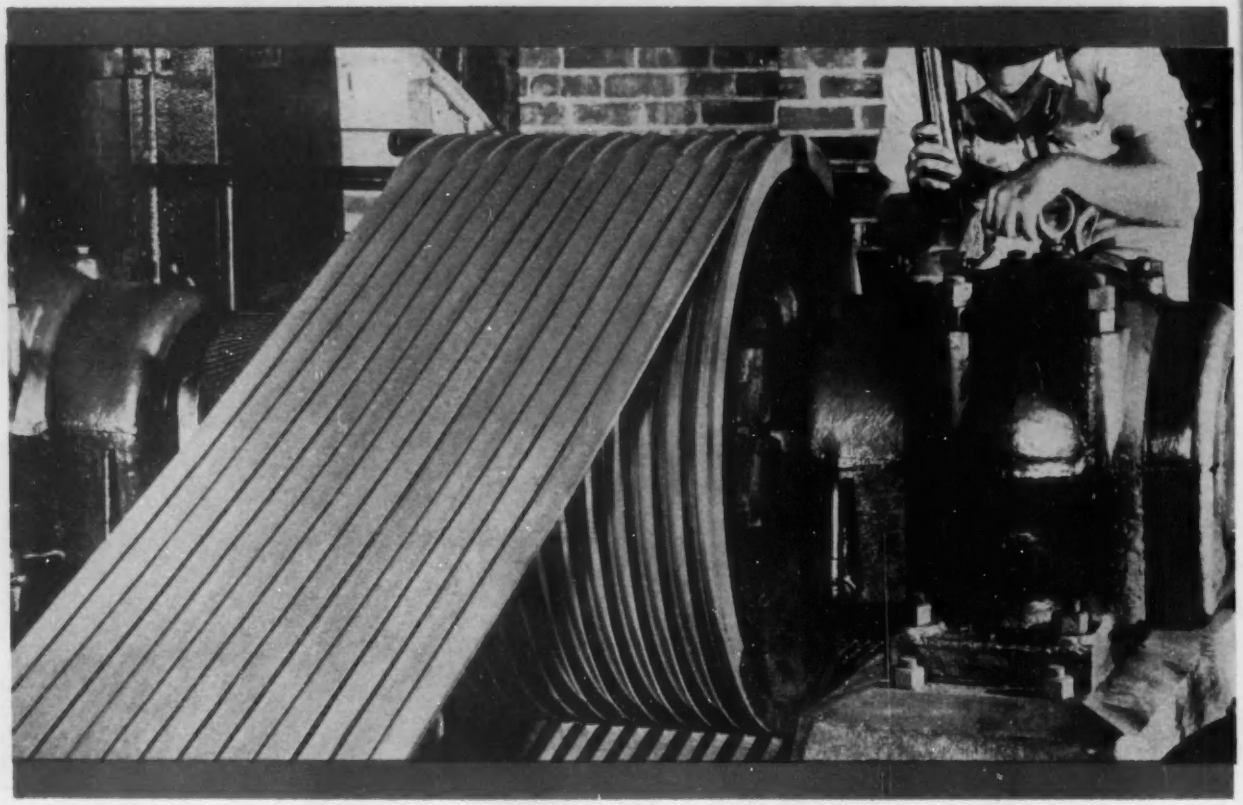
Name.....

Company.....

Address.....

City.....*Zone*...*State*.....

CALL ON R/M ENGINEERING SERVICE



40% MORE HORSEPOWER WITH NO CHANGE IN V-BELT DRIVE DESIGN

R/M SUPER-POWER V-BELTS have 40% greater horsepower capacity over an equal number of regular V-belts. A combination of new synthetic fibers in the strength member cords of R/M Super-Power V-Belts assures greater resistance to shock loads, minimum stretch, virtual elimination of matching problems, and rugged durability. R/M's Super-Power construction plus straight sidewalls mean better tensioning and grip, less slip, longer life . . . You can increase the horsepower of a drive as much as 40% without additional V-belts. On some drives, you can meet horsepower specifications with narrower sheaves and fewer belts.

The all-synthetic construction of R/M Super-Power V-Belts also provides oil-proof, non-spark, and heat resistant features. The tough, flexible fabric cover protects the belt against moisture absorption and shrinkage due to atmospheric changes. All parts are precision balanced in manufacture to provide the smoothest running V-Belt made. Write for Bulletin 6628, "R/M Super-Power V-Belts".

Whatever your requirements for mechanical rubber products, hose, belting, molded rubber and nylon, extruded or rubber-to-metal parts, R/M specialists are ready to work with you.

For booklet shown, or other data, write, phone or wire:

MANHATTAN RUBBER DIVISION
Raybestos-Manhattan, Inc.
Passaic, N.J.
Gregory 3-2000

R/M

SPECIALISTS IN ASBESTOS, RUBBER, SINTERED METAL, ENGINEERED PLASTICS

Brake Blocks, Linings and Clutch Facings

Fan Belts and Radiator Hose

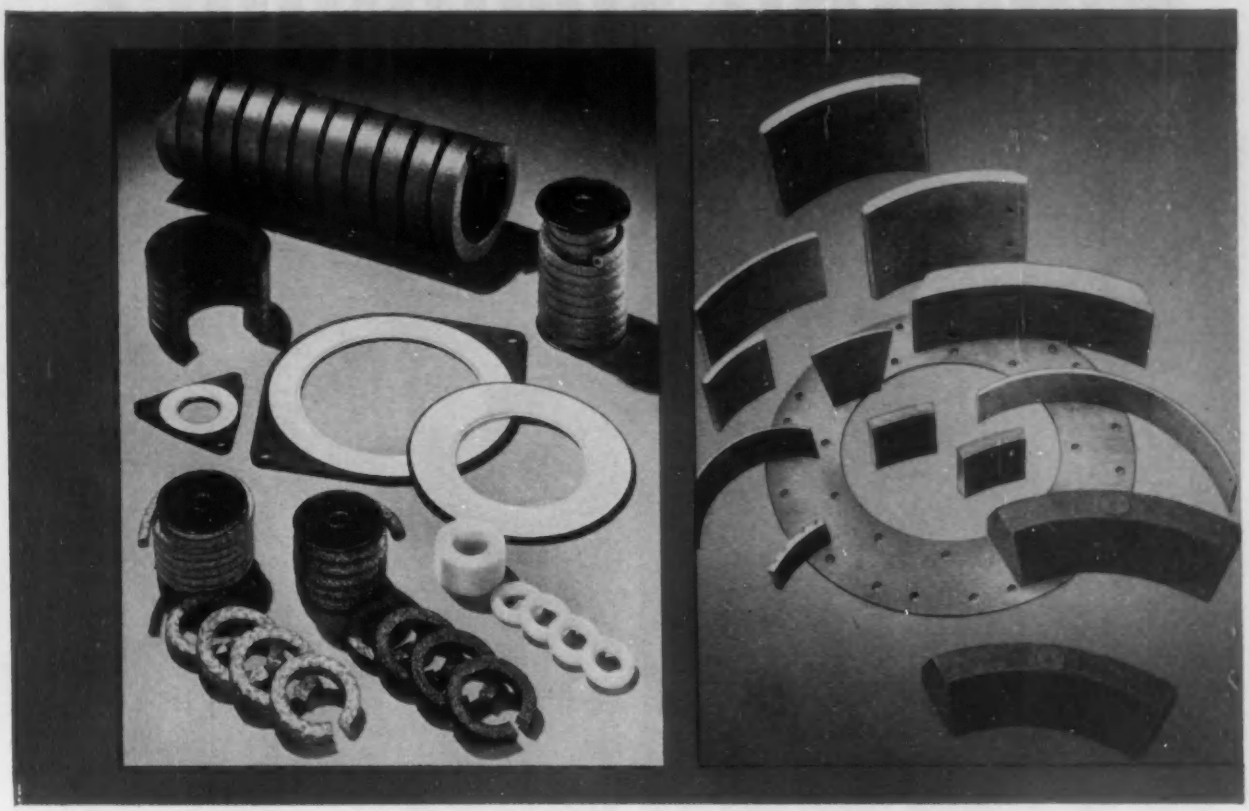
Mechanical Packings and Gaskets

Abrasive and Diamond Wheels

Industrial Drive Belts

Industrial and Automotive Hose

FOR HELP IN SOLVING YOUR PROBLEMS



PACKINGS, GASKETS, Asbestos Textiles and TEFLON* products

Pictured above are a few of the carefully engineered packings and gaskets Raybestos-Manhattan makes. The complete R/M line includes packings and gasket sheets for use against air, gas, water, steam, oil, chemicals, solvents, food products and hydraulic fluids. R/M also makes a wide variety of "TEFLON" products and an unusual number of asbestos textiles. If you have problems involving any of these materials or products, feel free to call on R/M's specialized engineering service. For complete information, send for booklet on packings, gaskets, and "TEFLON" products.

Du Pont's trade-mark for its tetrafluoroethylene resin

For booklet shown, or other data, write, phone or wire:

PACKING DIVISION OR ASBESTOS TEXTILE DIVISION
Raybestos-Manhattan, Inc.
Manheim, Pa.
Manheim 5-2211

FRICTION MATERIALS

If you have a problem involving friction materials, call on R/M's specialized engineering service. The advice you get will be unbiased, for Raybestos-Manhattan works in both the asbestos and metal fields—making many different woven, molded and sintered metal parts. The complete line includes innumerable shapes and sizes and covers a wide range of compositions, friction values, and characteristics. For detailed information about R/M brake linings, clutch facings, and special shapes of friction materials, send for booklet today.

For booklet shown, or other data, write, phone or wire:

EQUIPMENT SALES DIVISION
Raybestos-Manhattan, Inc.
6010 Northwest Highway
Chicago 31, Ill.
ROdney 3-2400

RAYBESTOS-MANHATTAN, INC.

FACTORIES: Passaic, N.J. • Bridgeport, Conn. • Manheim, Pa. • No. Charleston, S.C. • Crawfordsville, Ind. • Neenah, Wis. • Peterborough, Ontario, Canada

Conveyor Belts

Rubber Lined and Covered Equipment

Sintered Metal Friction Elements

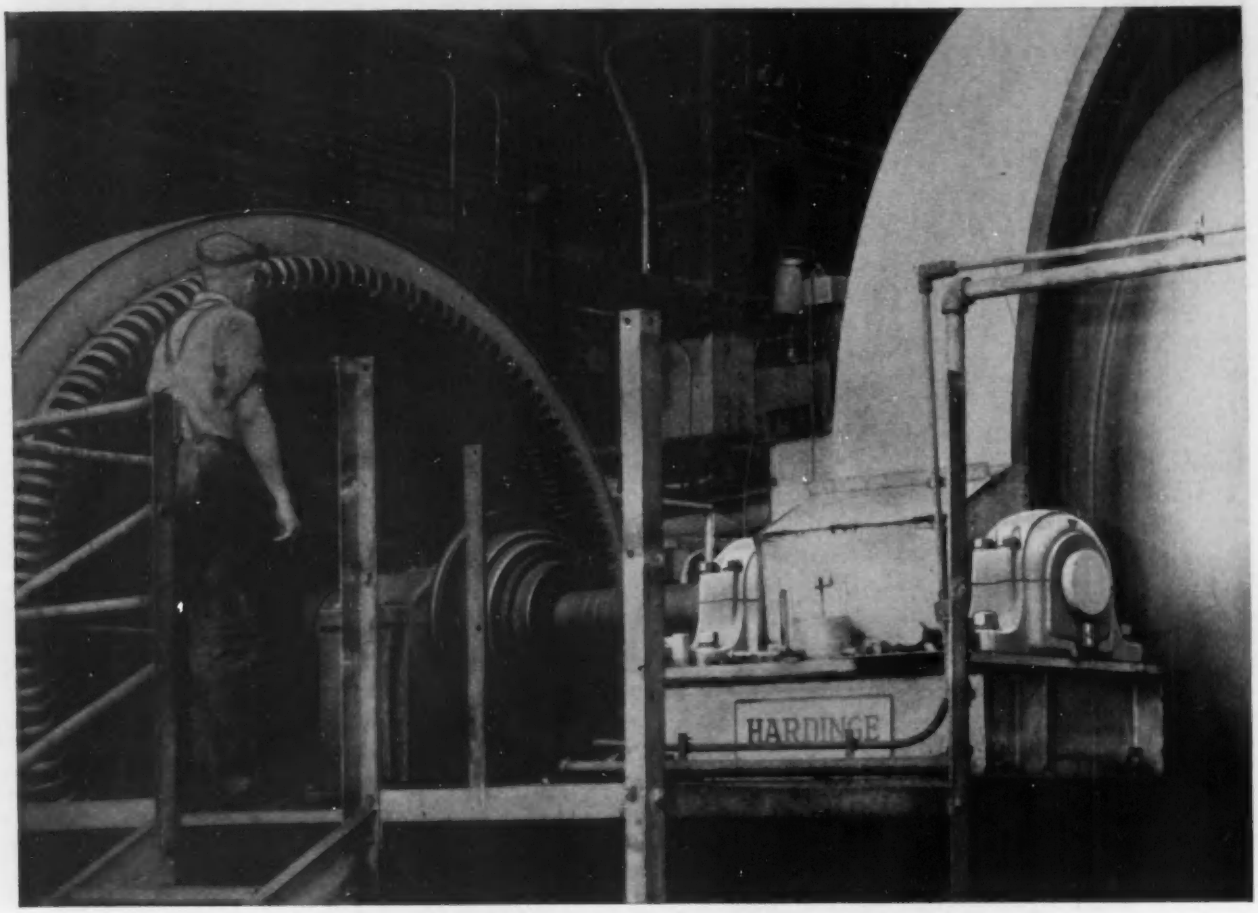
Asbestos Textiles

Teflon Tape, Packings, Sheets, Rods, Tubes

Engineered Molded Rubber and Plastics

RM

Bearing problem?



LINK-BELT ROLLER BEARINGS chosen for huge grinding mill

INSTALLATION of this Hardinge Tricone mill at Tennessee Copper Co. resulted in an important conservation of grinding energy. And to support the pinion shaft drives, Hardinge designers chose Link-Belt roller bearing pillow blocks.

Wherever friction must be minimized and power consumption reduced, you'll find Link-Belt bearings. Precision-built and positively sealed, they deliver long-life, free-rolling shaft support on the toughest jobs. That's why they're first choice of so many leading design engineers.

You'll find there's a Link-Belt ball or roller bearing for every industrial need. And there's a Link-Belt bearing engineer near you to help apply them to your particular requirements. Call him today, or write for your copy of Data Book 2550.

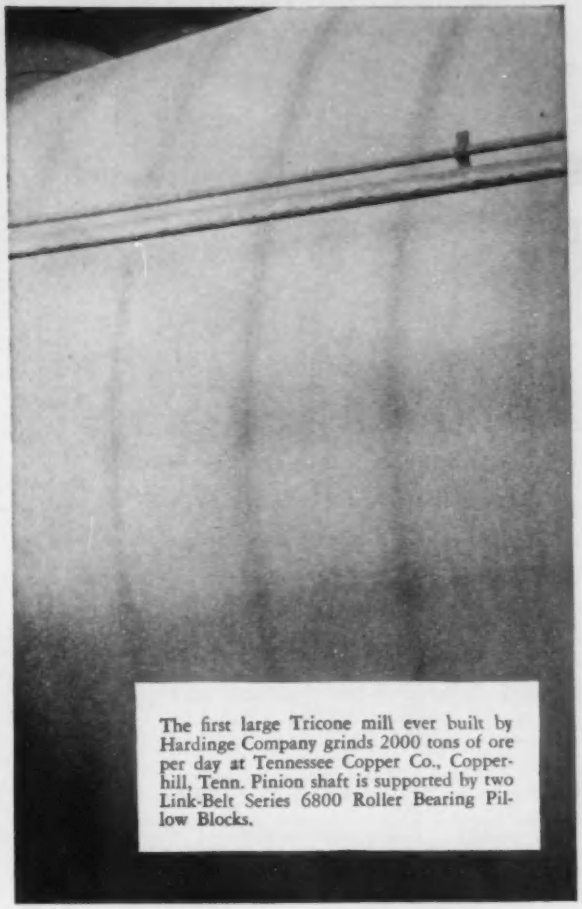
LINK-BELT COMPANY: Executive Offices, 307 N. Michigan Ave., Chicago 1. To Serve Industry There Are Link-Belt Plants and Sales Offices, Stock Carrying Factory Stores and Distributors in All Principal Cities. Export Office, New York 7; Canada, Scarboro (Toronto 13); Australia, Marrickville, N.S.W.; South Africa, Springs. Representatives Throughout the World. 13,369-DE

LINK-BELT

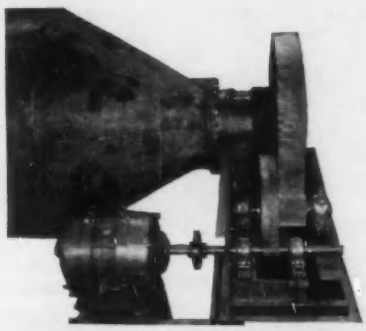
BALL AND ROLLER BEARINGS

LINK-BELT ball and roller

READY ANSWER!

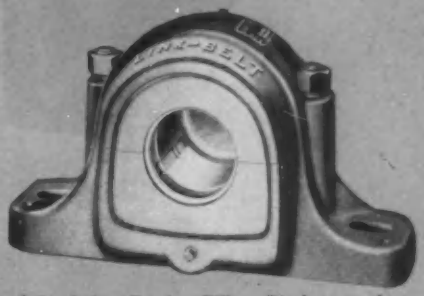


The first large Tricone mill ever built by Hardinge Company grinds 2000 tons of ore per day at Tennessee Copper Co., Copperhill, Tenn. Pinion shaft is supported by two Link-Belt Series 6800 Roller Bearing Pillow Blocks.

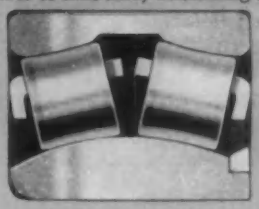


Hardinge also uses Link-Belt roller bearings on drive-shafts of many other grinding mills like this pebble mill.

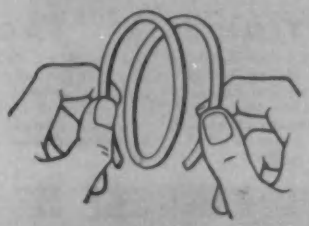
FACTS: for consulting and design engineers



Series 6800 Roller Bearing Pillow Blocks — used on the Hardinge mills — are part of Link-Belt's line of pillow blocks, flanged, flanged cartridge, cartridge, take-up and hanger blocks and unmounted bearings. Following are just four of their many outstanding features:

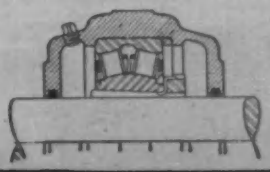


INTEGRAL SELF-ALIGNMENT. Concave rollers operate between convex raceways. Inner ring is true spherical element, free to turn in any direction without altering contact with rollers. Symmetrical rollers completely pocketed in retainers for accurate spacing and guiding. Long, care-free bearing performance is assured even with shaft deflection or misalignment.



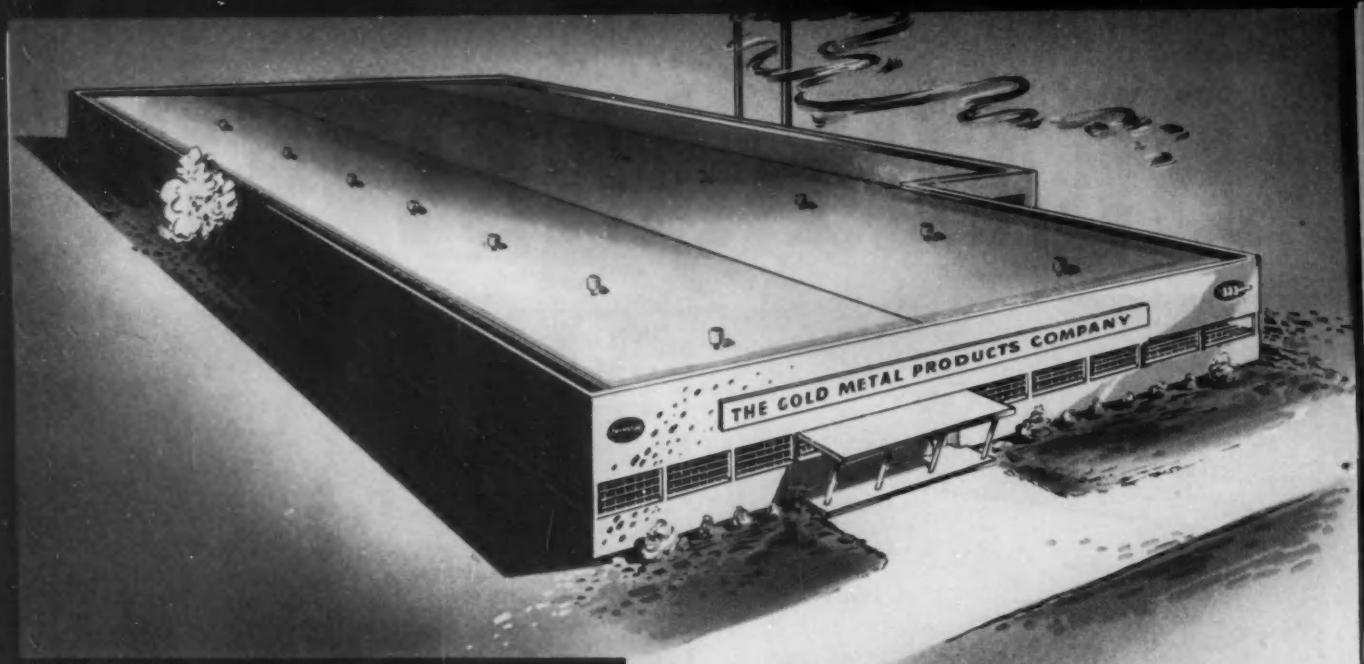
SPIRAL STEEL SEALS provide effective lubricant retentjon for either oil or grease. Housing sealing fully protects all moving surfaces which are centrally lubricated from a large, common reservoir.

END PLATE can be used for protection where shaft terminates at the bearing. No added machining is necessary.



INCREASED COMPACTNESS is achieved with self-contained design. There are no external rotating parts to mar smooth appearance.

bearings keep company with America's hardest-working machines



New CMP INDIANAPOLIS PLANT

This new additional plant of The Cold Metal Products Co. completes another step in the CMP expansion program. It's a special plant because it is technically engineered and equipped for the specialized production of the particular types of cold rolled strip and spring steel most needed by CMP customers in the mid-west area easily served from the Indianapolis location.

CONSTRUCTION

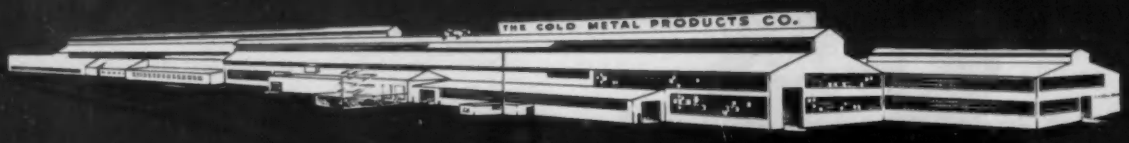
Constructed along lines of today's clean simplicity of structural design, it provides for the most efficient flow of material in process to net the lowest manufacturing cost practical for the special tolerances, structures and finishes characteristic of CMP strip and spring steel products.

FACILITIES

Included are CMP-Type designed and built 4-High cold rolling mills, annealing furnaces, slitters, pickle line and auxiliary equipment necessary to produce the high standard of quality generally identified with CMP strip and spring steel products.

LOCATION

On a 32 acre site at 2301 South Holt Road in suburban Indianapolis, CMP is the first company to recognize and provide for the steadily growing needs of the area as an important consumer of specialized flat rolled steel products.



YOUNGSTOWN PLANT AND GENERAL OFFICE

A COMPLETELY *NEW* PLANT . . .

FOR ADDITIONAL CMP PRECISION COLD ROLLED STRIP STEEL PRODUCTION

With the additional Indianapolis facilities now in operation and providing an increased tonnage of CMP strip all customers will benefit. Since more product will be produced more customers can be served and improved deliveries in all areas will result.

The fact that so many fabricators have turned to CMP for the cost saving and product improving advantages of "special spec" cold rolled strip and spring steel is forceful testimony to the importance of spending more time in checking the values CMP products can offer you.

THINSTEEL
TRADE MARK

PRECISION COLD ROLLED CMP STRIP STEEL

C M P

WORLD'S FASTEST In a trial run, "Slo-Mo-Shun IV" streaks over Lake Washington, Seattle, at better than 180 miles an hour.

What keeps her from flying to pieces?

Death crowds right into the cockpit beside you when you drive a boat like that.

Strange things happen. Every little wave jars the hull like a rutted road. Your foot burns at the touch of the jiggling accelerator. Your eyeballs jounce around in their sockets like glazed marbles as you keep watch for a sight you never hope to see:

Screw heads popping off like bullets as the beaten hull breaks up around you from the incessant pounding.

But that is one threat you no longer need to fear—not when your boat is held together with Anchorfast. Stan Sayres (he owns and drives the world's fastest boat) can tell you: Not even the varnish has cracked where her joints are nailed with Anchorfast.

What is "Anchorfast?" Just about the most revolutionary fastener you ever did see (at right). Once you drive it in, it can split the handle of a claw hammer before it budges a thread.

Anyone could see what a wonderful idea it was when the manufacturer came to INCO with his question: "What metal?"

It had to be strong and tough for holding power, of course. And hard and stiff so you could drive it into hard wood without bending. Yet so rust-free and durable that it would outlast wood. Not too expensive either, mind you, for Anchorfast would sell in competition with ordinary brass screws.

Monel fulfilled every requirement as if it had been an INCO Nickel Alloy especially made for Anchorfast.

Today you find Anchorfast in boats from "Slo-Mo-Shun IV" down to slow plodding work boats, in cooling towers, catwalks, mushroom trays—for any use where joints must stay tight as long as the wood lasts.

Does Anchorfast remind you of a metal problem in some product of your own? Let's talk it over. The International Nickel Company, Inc., 67 Wall Street, New York 5, N. Y.

The holding power of Monel Anchorfast comes from its unique "biting tooth" design. The wedged wood fibers lock into the grooves like dozens of tiny vises. Like to try it yourself? Write for "Anchorfast Test Sample."

Inco Nickel Alloys

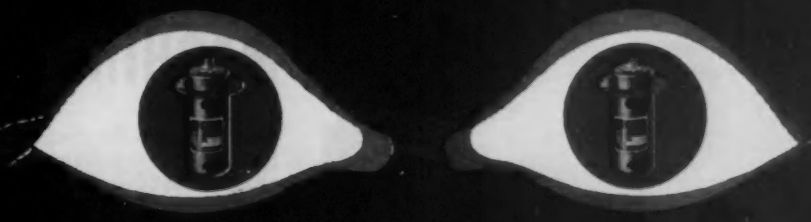
INCO

Monel® • "R"® Monel • "K"® Monel "KR"® Monel • "S"® Monel • Nickel Low Carbon Nickel • Duranickel® Inconel® • Inconel "X"® • Inconel "W"® Incoloy® • Nimonic® Alloys

HIGH LEVEL

CONSTANT LEVEL

LOW LEVEL

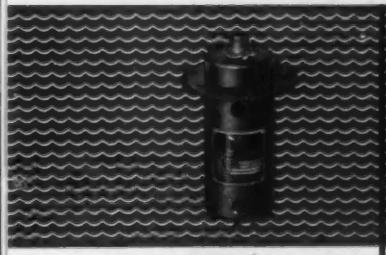


Revere INSTRUMENTS SEE WHERE YOU CAN'T

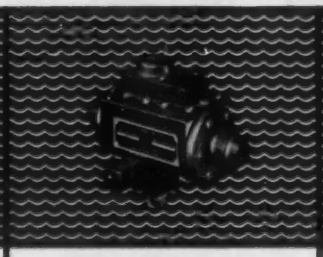
See *Revere* . . . if you need to know — **HOW MUCH LIQUID — HOW LITTLE — AT WHAT LEVEL.** *Revere's* precision made instruments are your unfailing eyes that see into sealed tanks, tubes or complex fuel lines. They can provide you with accurate measurement of liquid level regardless of pressure or temperature changes, vibration or rapid acceleration forces, AND they will automatically transmit a warning signal whenever liquid flow or level maintenance varies from a pre-determined value.

These hermetically sealed, magnetically actuated instruments employ balanced float assemblies to minimize false alarms. Compact and light, Revere instruments meet government specifications. They are available in many different configurations, some of which include relays to handle heavy electrical loads. Others are designed for complete submersion in fluids.

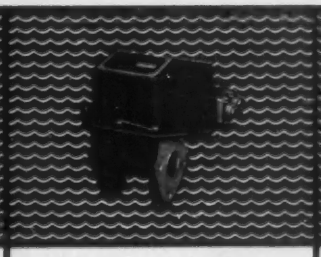
*Submit your control problem to our Field Engineering Department today. Revere will provide the instruments to tell you — **HOW MUCH — HOW LITTLE — AT WHAT LEVEL.** Shown below are some instruments that are the seeing-eyes of aircraft and industry.*



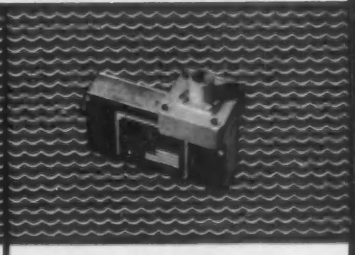
FLOAT SWITCH
Specially designed with single or dual float systems to provide automatic cut-off control for single point high pressure refueling.



FLOW SWITCH
Provides instantaneous warning signal whenever liquid flow falls below a pre-determined value. It can be mounted in any direction.



INDICATING SWITCH
Records the presence of fluid in a line whether stationary or flowing and transmits a warning signal if fluid condition changes.



FLUID LEVEL SWITCH
Used to maintain accurate high level, low level or constant level control of fuels, water-alcohol mixtures, beverages, etc. and other liquids.

SEND FOR FREE BULLETINS

REVERE CORPORATION OF AMERICA
WALLINGFORD 2, CONNECTICUT, U. S. A.
precision instruments for aircraft and industry

Here's How the Revolutionary

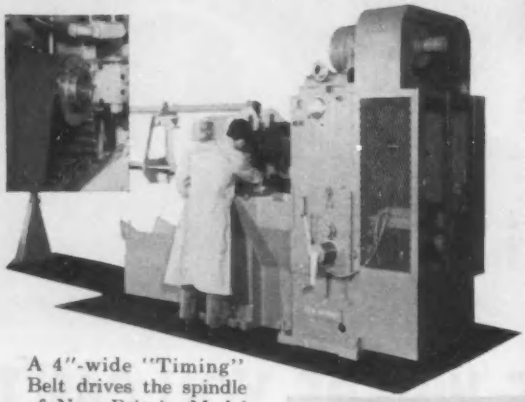
ORIGINAL

Gilmer "TIMING"®

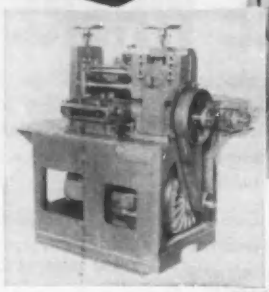
has been enthusiastically adopted by America's

MACHINE TOOL INDUSTRY

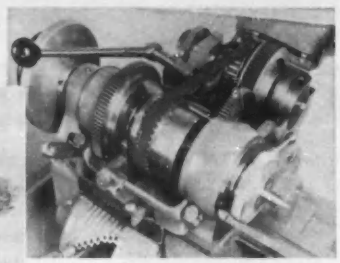
MACHINE TOOL designers have found in the Gilmer "Timing" Belt Drive a superior means of transmitting power more quietly, more efficiently, more economically, with more precise synchronization, and at constant angular velocity. On metal cutting and grinding machines the "Timing" Belt Drive has shown the way to minimize vibration and tool chatter, resulting in finer surface finish. Shown here are only a few representative machine tools now making use of Gilmer "Timing" Belts on their most vital drives.



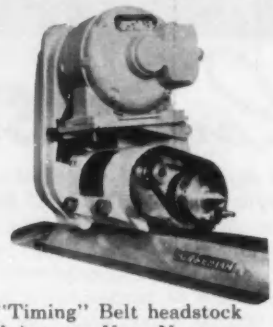
A 4"-wide "Timing" Belt drives the spindle of New Britain Model 126 Automatic Bar Machine.



Ruesch #149 Gang Slitter employs 3 *stock* "Timing" Belt Drives from 20 HP motor.

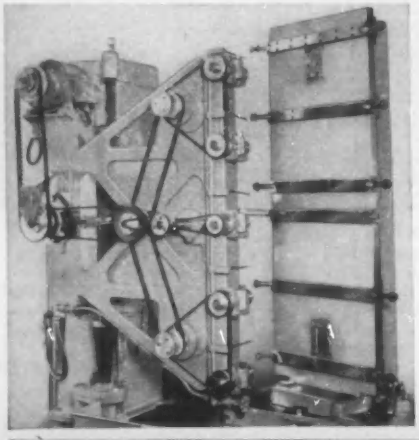


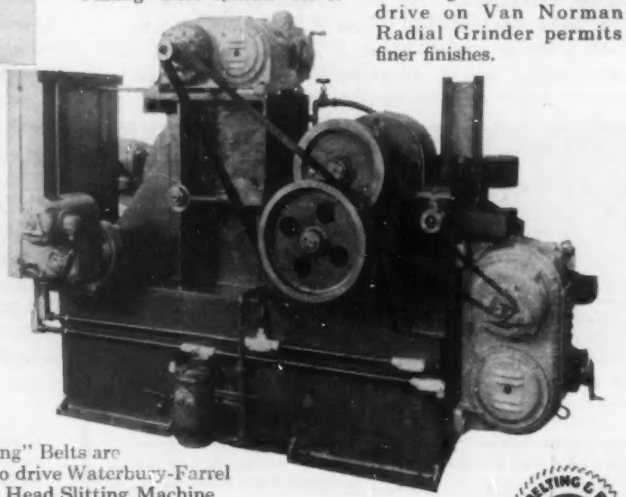
Wade Precision Lathe uses "Timing" Belt spindle drive.



"Timing" Belt headstock drive on Van Norman Radial Grinder permits finer finishes.

Eight "Timing" Belt drives provide excellent carbide tool life and finishes on Pratt & Whitney Duplicator.





"Timing" Belts are used to drive Waterbury-Farrel Screw Head Slitting Machine.

NEW YORK BELTING & PACKING CO. Founded 1846

NYB&P

BELT DRIVE

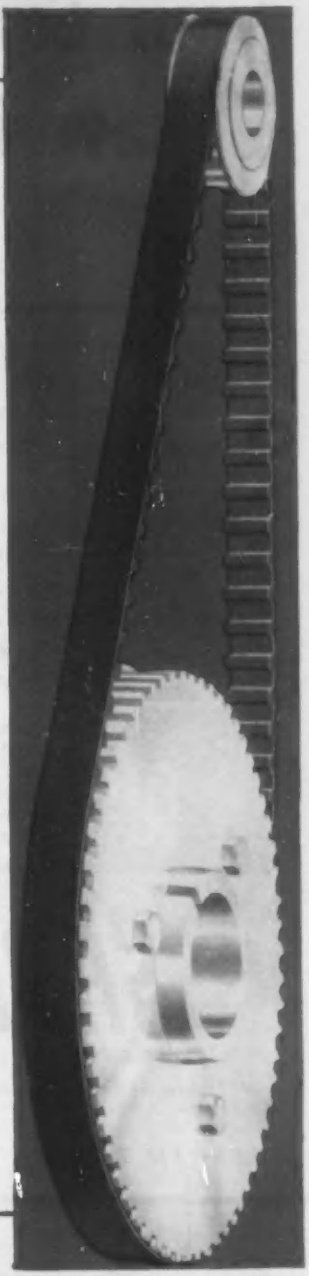
Industry's New Power-Transmitting Medium

Sweeps away design restrictions

In one application after another, "Timing" Belt Drives have enabled machine designers to achieve basic engineering improvements—or to design entirely new machines—that were previously either impractical or impossible! For never before has there been a *positive drive* that combined all these desirable characteristics:

- **Requires no lubrication, no housings or lubricant guards.**
- **Maintains precise synchronization ("timing") between shafts.**
- **Provides speed ratios as high as 15 to 1 in a single step.**
- **Operates satisfactorily at speeds from inches per hour to 15,000 fpm.**
- **Permits use of very small diameter pulleys for ultra-compact drives.**
- **Has nearly 100% mechanical efficiency.**
- **Needs no initial tension. Lighter bearing loads permit lighter bearings.**
- **Does not stretch or lengthen with use; requires no take-up.**
- **Can be designed for zero backlash.**
- **Capacity ranges from 1/100 to 300 horsepower.**

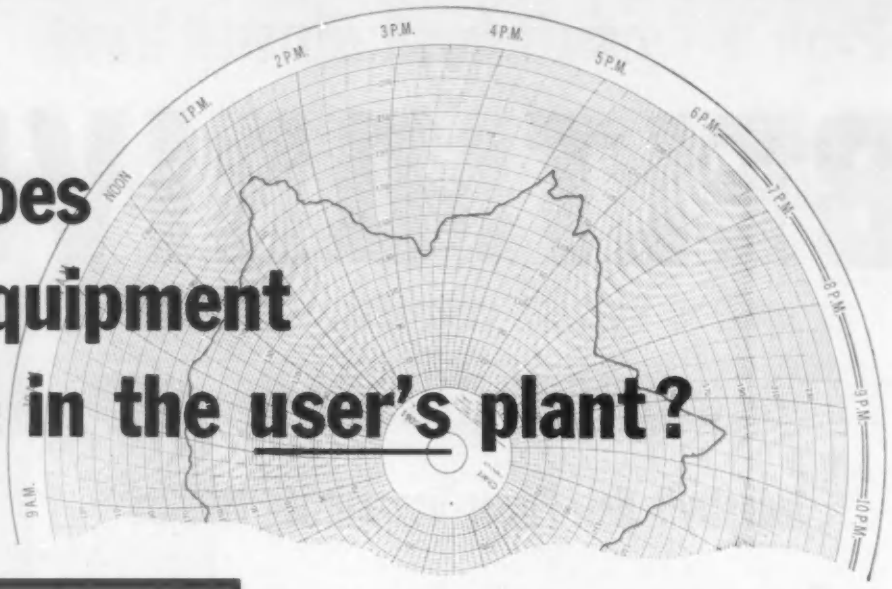
These are but a few of the unique features of this amazing tooth-grip belt drive that is already in successful use on hundreds of thousands of machines. Consult your local NYB&P Distributor—or write direct for the new 76-page Gilmer "Timing" Belt Standard Drive Manual listing hundreds of drives now available promptly *from stock*. Address Gilmer "Timing" Belt Division of New York Belting and Packing Co., 1 Market Street, Passaic, N. J. or phone PRescott 7-6940.



NEW YORK BELTING & PACKING CO. 1 Market St., Passaic, N. J.

America's Oldest Manufacturer of Industrial Rubber Products

How does your equipment behave in the user's plant?



Sarco specialties and know-how can help you eliminate the many obscure causes of such problems as:

Heating and Cooling Coils and Jackets

- Poor heat transfer
- Slow heat-ups
- Erratic temperatures
- Water-hammer
- Corrosion
- Excessive Steam Costs
- Waste of Cooling Water

Problems like these are better solved *before* they reach your customers — don't hesitate to call on Sarco engineering service.

SARCO

SAVES STEAM

improves product quality and output

STEAM TRAPS, temperature controllers and other steam accessories can, if improperly specified or installed, jeopardize the operation of your original equipment in the plant.

If the user installs the wrong type of steam trap, the unit may waterlog intermittently. Improper installation of a temperature controller may cause erratic temperatures in the unit. The lack of an air vent may cause slow start-up, poor heat transfer.

Problems like these, though no fault of the original equipment, reflect on the manufacturer's reputation and lead to loss of good will and business.

You can avoid this risk by taking advantage of Sarco's extensive experience as designers and manufacturers of a complete line of steam traps and regulators for the process industries.

Sarco engineers have saved many a manufacturer time, trouble, and expense with sound and impartial recommendations on all phases of steam trapping and temperature control.

For interesting case histories describing the solution of process heating and cooling problems similar to yours, write today to Sarco Company, Inc., Empire State Bldg., New York 1, N. Y.

STEAM TRAPS • TEMPERATURE CONTROLLERS • STRAINERS

Thermostatic Steam Traps

Bulletin 250

Float-Thermostatic Steam Traps

Bulletin 450

Camlift Bucket Steam Traps

Bulletin 360

Liquid Expansion Steam Traps

Bulletin 260

Thermodynamic Steam Traps

Bulletin 255

Strainers

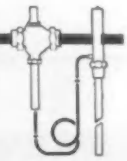
Bulletin 1200

Water Blenders

Bulletin 800

Electric Temperature Controllers

Bulletin 1025



Self-Operated Temperature Controllers

Bulletin 600

Plan your future products with BAKELITE TRADE-MARK Polyethylene for better performance, economy, sales appeal

Now is the practical time to start planning with BAKELITE Polyethylene. The future—increased supply as a result of planned production expansion—comes closer every day.

When you consider this material in the light of product re-design, you will find a great many ways to take advantage of BAKELITE Polyethylene's unusual combination of advantageous properties.

You may be able to apply its impact strength, dielectric properties and ease of fabrication to critical design problems...or determine how its light weight, flexibility and corrosion resistance can give your new products-to-be an edge in performance, saleability, and manufacturing cost reduction.

The many properties, plus examples of uses, are shown in our 24-page booklet, BAKELITE *Polyethylene*. Write for your free copy today to Dept. TU-10.

BAKELITE TRADE-MARK **Polyethylene**

BAKELITE COMPANY, *A Division of Union Carbide and Carbon Corporation* UCC 30 East 42nd Street, New York 17, N. Y.

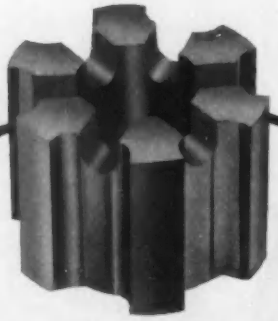
In Canada: Bakelite Company, Division of Union Carbide Canada Limited, Belleville, Ontario

WATER IS THE ONLY LUBRICANT YOU

GRAPHITAR® BEARINGS

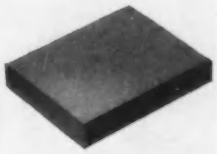
In various types of pumps and pump motors, rotary pressure joints, torque converters, turbines and similar applications where water or steam is present, GRAPHITAR makes a highly successful bearing material, because GRAPHITAR operates efficiently under heavy loads with water as the only lubricant. This is possible for two reasons: 1.) GRAPHITAR has a lower coefficient of friction than any other bearing material; and 2.) GRAPHITAR is porous and maintains an adequate water film at the bearing surface. In applications where the bearings are relatively inaccessible, the advantage is obvious, for GRAPHITAR eliminates bearing maintenance.

TIN LINE BEARING

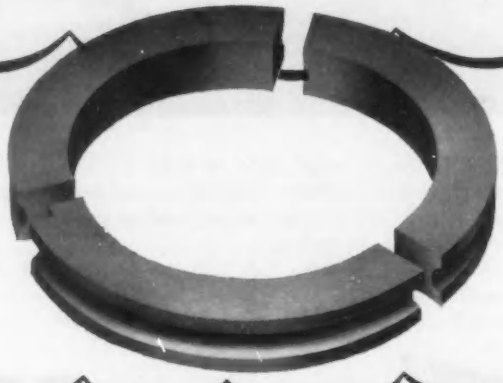


SLOTTED WATER PUMP BEARING

WATER PUMP VANE



STEAM TURBINE RING



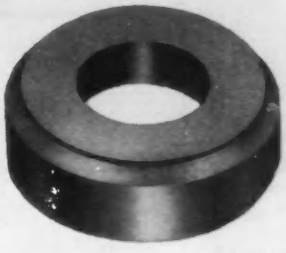
THE UNITED STATES

OUR 100TH YEAR

NEED FOR

ROTARY PRESSURE JOINT BEARING

STEAM VALVE ROTOR



THRUST WASHER

DEEP WELL PUMP BEARING

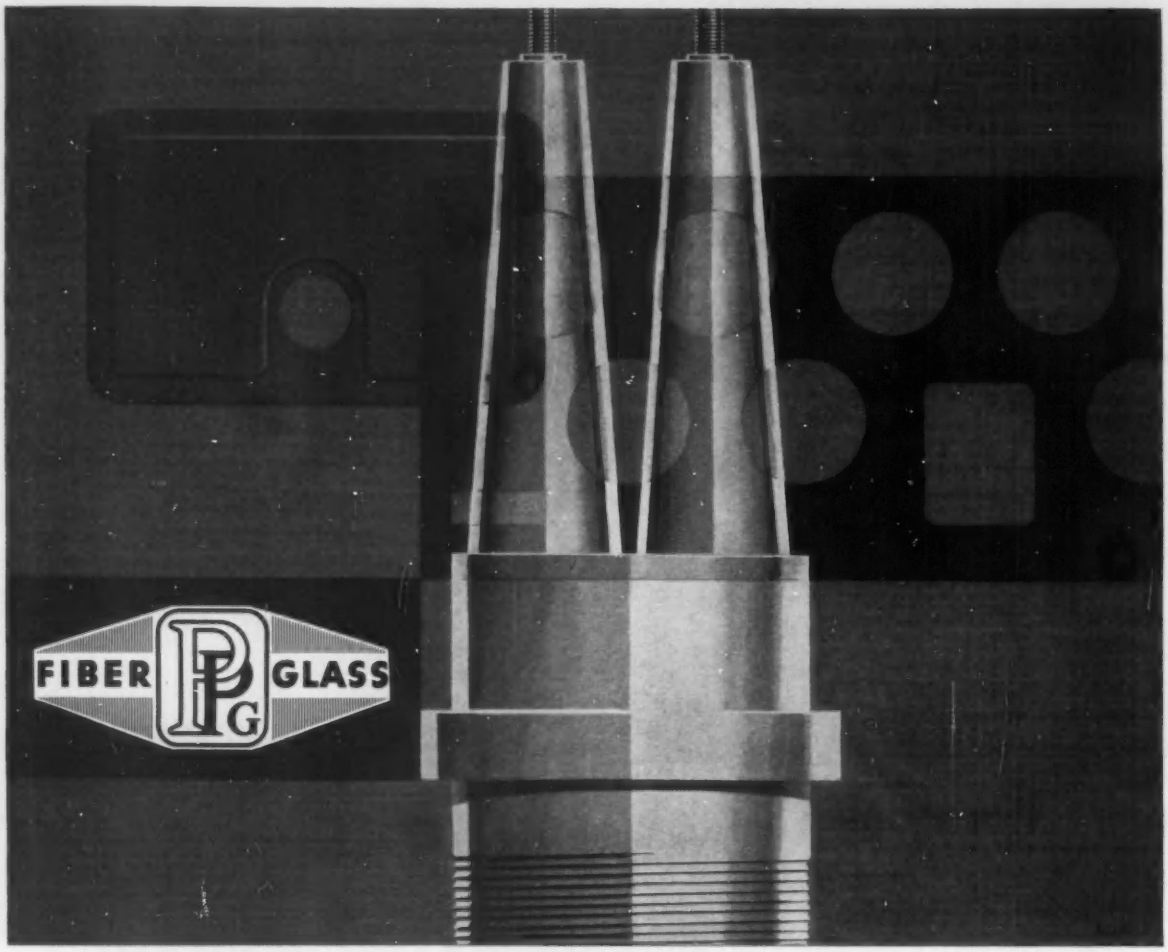
GRAPHITAR is a versatile engineering material produced from carbon-graphite powders, compacted under terrific pressures and fused at temperatures up to 4500° F. It can be formed in relatively complicated shapes and ground to tolerances as close as .0005" for seals, bearings, vanes, piston liners and many other parts. In hundreds of difficult applications, GRAPHITAR has proved to be the only completely successful material. GRAPHITAR is lightweight, strong and durable, chemically inert, and virtually unaffected by high speeds, high pressures or temperature extremes. Write today for our illustrated 64-page GRAPHITAR catalog.

WATER PUMP SEAL

186

GRAPHITE COMPANY

DIVISION OF THE WICKES CORPORATION, SAGINAW, MICHIGAN



To make your component parts better, safer, lighter, stronger, specify Pittsburgh Fiber Glass reinforcements

Virtually hundreds of new uses for Pittsburgh Fiber Glass are being discovered yearly by industry as a result of the unusual properties it economically adds to manufactured parts of all types. Exceptional strength, and dimensional stability is added to improve the function and durability of all types of rubber, plastics and paper parts when reinforced with Pittsburgh yarns.

Electrical housings and structural parts gain excellent dielectric strength when Pittsburgh Fiber Glass reinforcing cloth is specified for laminates. Improved insulation is gained when Pittsburgh yarn is used for wire and cable insulation, wire sleeving and tubing.

Check into the profitable facts on Pittsburgh Fiber Glass for use in your product's design and construction—you can get complete information and technical staff assistance through our executive offices or district sales offices in Chicago, Cincinnati, Cleveland, Detroit, New York or Washington. Pittsburgh Plate Glass Company, Fiber Glass Division, One Gateway Center, Pittsburgh 22, Pennsylvania.

FIBER GLASS PAINTS · GLASS · CHEMICALS · BRUSHES · PLASTICS

PITTSBURGH PLATE GLASS COMPANY

A service for

early birds

engineering new metal products

...early birds
are sheet metal design engineers and production men who make a point of getting the gremlins out of new products or new models in early stages...

If you're an EARLY BIRD, here's a new service you'll appreciate.

It starts when engineers of National Lead's Tool & Stamping Department go over your designs, looking for production bugs and ways to cut costs.

Next step is to cast try-out tooling, in "Kirksite" A or "Nalcolite" plastic ... and to make up the parts in the stock you want.

After that, National Lead assembles pilot models ... as many as you want.

Once dies, parts, and pilot models are proved to your satisfaction, the try-out tooling goes to you for medium-run production or for duplication in steel when you plan extremely high production.

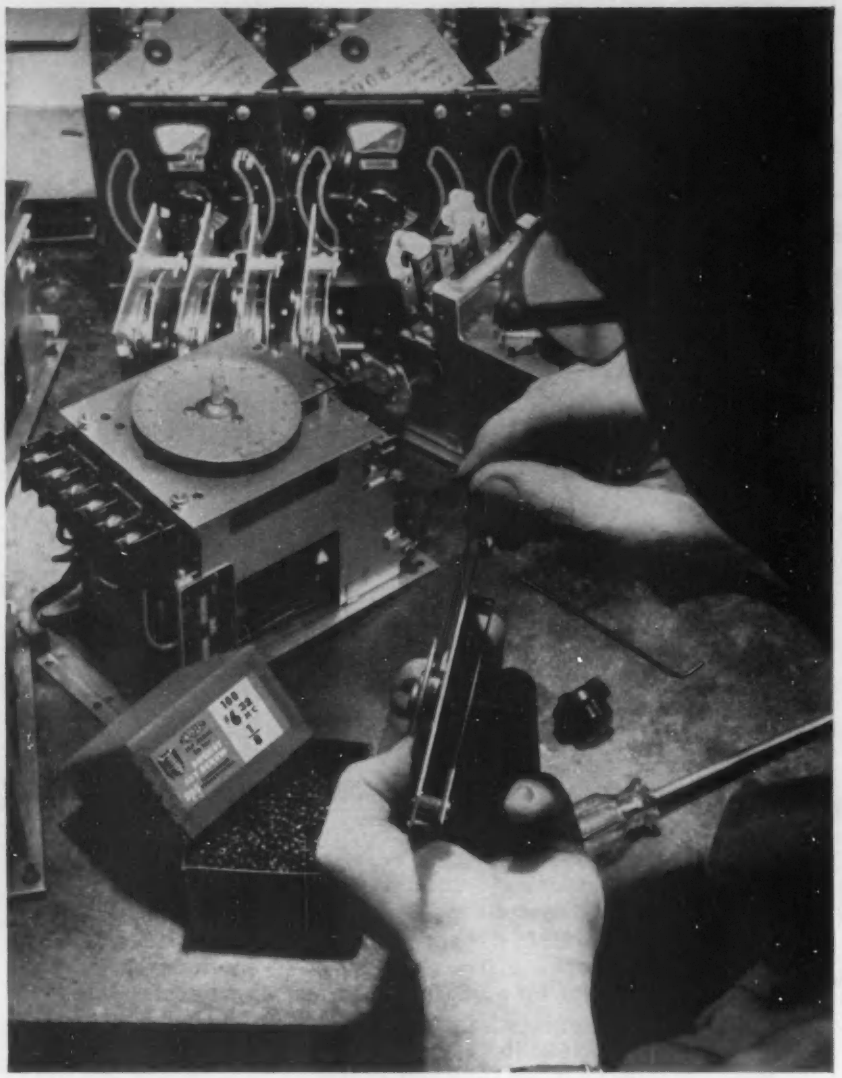
By the time you're ready for full scale production, every procedure, every cost is *proved*.

Just chirp up if you would like to know more about this new Tool & Stamping Department service.

National Lead Company

900 West 18th Street
Chicago 80, Illinois

TOOL & STAMPING DEPARTMENT



UNBRAKO Self-Locking Socket Set Screws are used to hold the Vernier-Set or Cycle-Progress cam on the shaft of this precision timing device. Once they are tightened, they maintain the accurate setting so important to the operation of the instrument.

Because they are so tiny, the UNBRAKO set screws are picked up and started in the tapped hole with the long arm key.

The compactness of the design of the timing device makes it necessary to turn the screw in prior to assembly. The uniform depth and size of the hex socket permit maximum torquing, speed assembly.

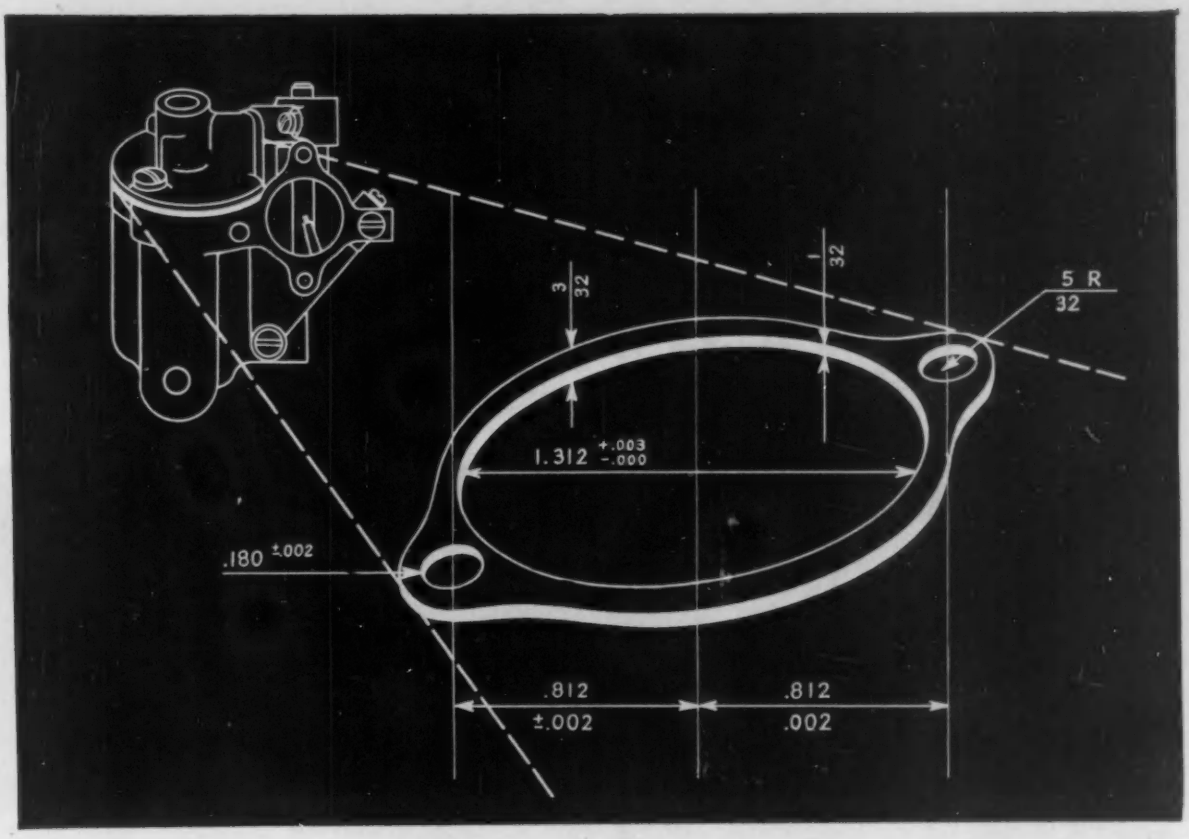
UNBRAKOS—made of heat treated alloy steel—have fully formed threads, Class 3 fit; have knurled cup point for positive locking. Are available in standard sizes from # 4 to 1".

You can lower your inventory by using UNBRAKO Standards—stocked by your distributor

You'll have less money tied up in inventory, you'll get personalized service, faster deliveries. In addition, you'll reduce assembly time and increase production with these precision industrial threaded fasteners. Write for UNBRAKO Standards—a complete listing of socket screw products made by SPS and stocked by your local distributor. STANDARD PRESSED STEEL CO., Jenkintown 28, Pa.

UNBRAKO® SOCKET SCREW DIVISION

SPS JENKINTOWN PENNSYLVANIA



New fiber gasket solves corrosion problem

When choosing gaskets, it's well to consider that gaskets sometimes cause trouble in other ways than by leakage.

Take the case of the carburetor shown above. Examination of carburetors returned to the factory showed that corrosion was the major reason for complaints. The cause of this was traced to the float bowl cover gasket. The glue-glycerine saturant in this treated fiber gasket absorbed moisture and permitted electrolytic action between the zinc and aluminum die castings and adjoining brass parts.

The manufacturer found a solution to his problem in an entirely new type of fiber gasketing—Armstrong's Accopac®. Accopac contains no hygroscopic agent; it does not encourage electrolytic action. Accordingly, when Accopac CN-705 was put in service on this carburetor, corrosion complaints dropped to zero.

Fibers locked in rubber. Why doesn't Accopac absorb water? The answer lies in the way it's made—a new beater saturation process that covers each fiber in an Accopac sheet with rubber latex *before* the sheet is formed. This locks the fibers in a uniform, closely controlled rubber coating. The resulting sheets are tight, impervious, and relatively unaffected by high humidity.

Today, Accopac has found wide acceptance wherever there's a need for efficient sealing at low cost. This new material is used in pumps, engines, automatic washers, aircraft and automotive equipment, and a wide variety of other applications.

FREE 24-PAGE GASKET MANUAL. Send for "Armstrong's Gasket Materials," 1954 edition. Contains information on specifications, tolerances, joint design, etc. See it in Sweet's product design file. For your own copy, write today to the Armstrong Cork Company, Industrial Division, 7003 Irvin Street, Lancaster, Penna.

ARMSTRONG'S ACCOPAC

These are the working with the to make your

AT LEBANON there are electric furnaces capable of melting up to 8500 pounds—induction furnaces with 2000-pound maximum capacities. Here, too, special Swiss* molding and production processes are combined with the finest in American methods and procedures. The CENTRI-DIE* process for making centrifugal castings in permanent molds—a process *introduced* in this country by Lebanon—provides the highest quality castings for difficult corrosion and heat resisting services. Pattern-making, core-making, heat-treating, finishing and cleaning complete the picture of equipment that produces Lebanon CIRCLE Ⓛ castings.

But equipment is not the whole story. Lebanon

CIRCLE L

CARBON, SPECIAL ALLOY AND STAINLESS STEEL CASTINGS

LEBANON STEEL FOUNDRY

LEBANON—PENNSYLVANIA

right men

right equipment

STEEL CASTINGS

foundrymen add immeasurably to the high quality of CIRCLE Ⓛ engineered products. These workers are craftsmen in every sense of the word, men trained and highly skilled, men dedicated to doing all they can to make your castings *right.*

If the pictures on these pages could talk they'd say, "Here's where equipment and craftsmen make Lebanon CIRCLE Ⓛ castings to a *high standard*—not to a price!" We believe sincerely that there is no economy in buying just by price . . . it is far better to buy the best product at a reasonable cost.

LEBANON STEEL FOUNDRY • LEBANON, PA.

*Special processes acquired from George Fischer, Ltd., of Switzerland. Lebanon Steel Foundry was also the original licensee for the centrifugal casting process developed by Firth-Vickers Stainless Steels, Ltd., Sheffield, England.

Lebanon Steel Foundry
56 Lehman St., Lebanon, Pa.

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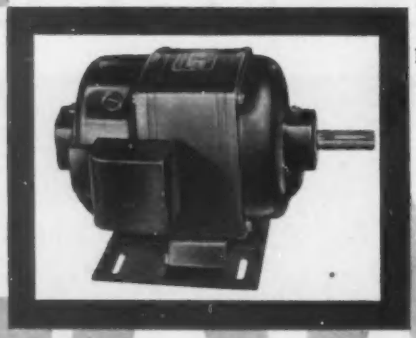
Get *your* Lebanon Slide Chart *now* . . .

This handy slide chart gives you the nominal analyses, various designations, minimum mechanical properties and heat treatment for 19 Lebanon carbon and low alloy grades and 17 stainless and corrosion-resistant grades. Send coupon today . . .

Leland Type PA Polyphase Induction Motor in drip-proof frame; 1/6 to 5 HP.

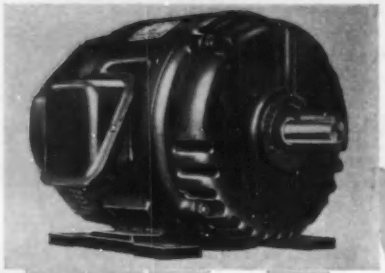
Leland Fan-cooled, Explosion-Proof (U.L. Class 1, Group D) Motor; single phase, polyphase or DC; 1/6 to 5 HP.

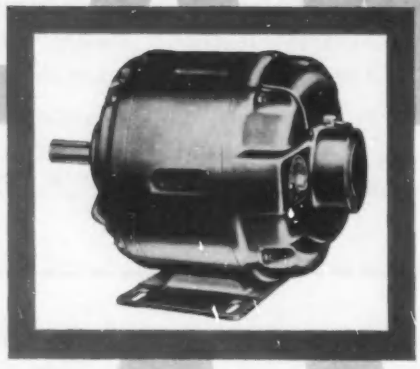


Leland Type DM Direct Current, General Purpose Motor in drip-proof frame; 1/6 to 5 HP.

Leland Type KL Single Phase, Capacitor Start, Induction Run Motor in drip-proof frame; 1/6 to 3 HP.

Leland Type RA Single Phase, Repulsion Start, Induction Run Motor in drip-proof frame; 1/3 to 5 HP.





Leland Type KS Split Phase, Induction Motor in drip-proof frame with thermal protection; 1/6 to 1/3 HP.

Though your only special need is Higher Quality...Look to Leland!

LELAND caters particularly to manufacturers who wisely demand *special quality* in *standard types* of motors, as well as those whose products require motors with special features or modifications.

We at Leland have always been keenly conscious of the unique part a good motor plays in product performance and user satisfaction. That's why we have—for more than 30 years—built Leland motors to highest standards of quality...never down to a price!

Under this policy, our engineers work closely and effectively with our customers to provide Leland motors—either standard or special—which meet exactly the application's particular requirements. As a result, Leland motors have established enviable records for trouble-free service in many fields.

Even though your only *special* motor need may be for higher quality, look to Leland to provide it. In the range between 1/6 and 5 HP, the selection of types and sizes is exceptionally broad. Write or wire for location of our local representative.

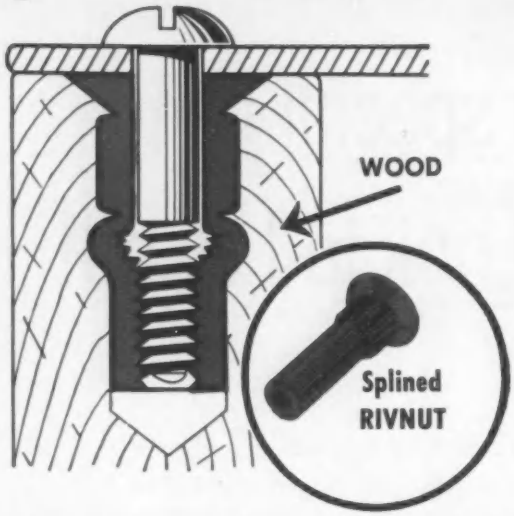
The LELAND ELECTRIC Co.

DAYTON 1, OHIO

Division of AMERICAN MACHINE & FOUNDRY COMPANY, New York
In CANADA, Leland Electric Canada, Ltd., Guelph, Ontario

AMF products are better...*by design*

B. F. Goodrich RIVNUT set in wood gives 6 clean threads for fastening

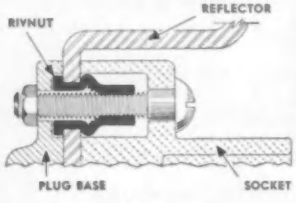


B. F. GOODRICH RIVNUTS eliminate use of wood screws where their frequent removal quickly wears away the wood. Imbedded and upset in wood, a BFG Rivnut provides at least six clean threads for screw attachment. Bulge formed by upsetting with easy-to-use heading tools holds Rivnut fast. Splined shaft or key in Rivnut head provides needed torque resistance.

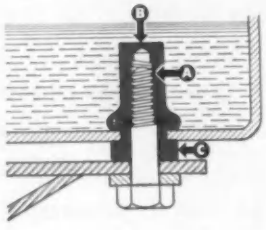
One manufacturer now uses splined Rivnuts to fasten the backs of television sets (see application at left). Screw holes in the cabinet were wearing too big from removal of wood screws.

The splined Rivnut is only one of many types of Rivnuts that solve tough fastening problems in wood, metal, plastic, many other materials. Rivnuts can be installed by *one* man from *one* side of the work in *two* seconds. They can be installed after enameling without marring finish. They save time, cut production costs, make products better. Consult a Rivnut engineer for help with *your* fastening problem. For complete information, write The B. F. Goodrich Company, Dept. PE-34, Akron, Ohio.

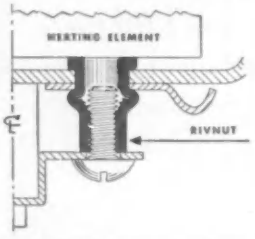
If you have fastening jobs like these, get B. F. Goodrich RIVNUTS



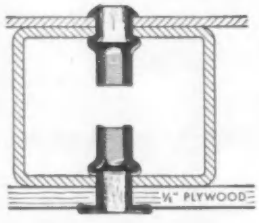
1. DOES 2 FASTENING JOBS! B. F. Goodrich Rivnuts fasten spotlight socket to reflector; same screws hold plug base to reflector. Former method demanded piercing, tapping, welding operations.



3. ELIMINATES BRAZING! Rivnuts with closed end (B) are installed in one-tenth the time it took to braze nut plates on oil reservoir tanks. Leaking, warping and thread cleaning are eliminated (A). Spacer head (C) positions tank.



2. ELIMINATES REINFORCING PLATE! In assembly of vaporizers, Rivnuts do away with reinforcing plate, don't turn under torque, hold flange securely without bending. Result: less assembly time, fewer parts, better product.



4. FASTENS PLYWOOD TO STEEL! Easier to install than wood or self-tapping screws, Rivnuts fasten plywood walls to tubular steel sections in trailers. No wood filler needed.

B.F.Goodrich

RIVNUTS

The only one-piece blind rivet with threads

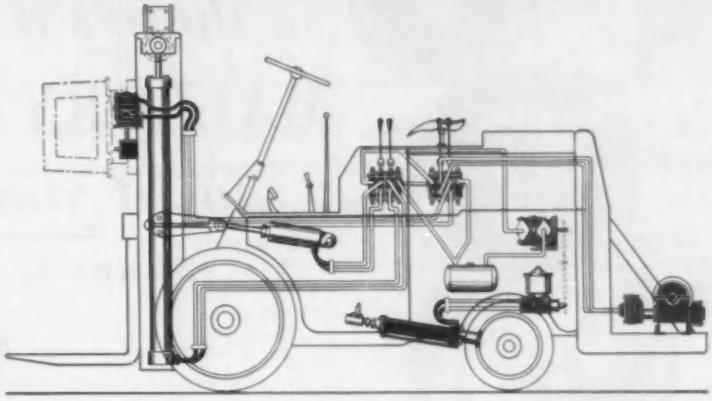
SEND NOW FOR FREE RIVNUT DEMONSTRATOR

Demonstrates with motion how you can use Rivnuts to fasten TO *and* fasten WITH. Explains construction, gives proved applications . . . Write for your free copy today to The B. F. Goodrich Company, Department PE-34, Akron, Ohio.

VICKERS® HYDRAULICS

The MARK of SUPERIOR MATERIALS HANDLING EQUIPMENT

Fork lift truck uses Vickers Hydraulics in one circuit for lift, tilt, roll-over, and winch operation. A separate circuit provides Vickers hydraulic power steering.



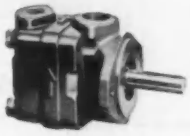
ASK FOR NEW BULLETIN M-5101

"Vickers Hydraulics" on materials handling equipment denotes superiority in two ways: First, the maker has obtained the benefits of the best in hydraulic equipment. Second, such care in the selection of hydraulic units generally denotes good design and careful construction throughout.

Among the important advantages of Vickers Hydraulics are simplicity of hydraulic design and of installation, complete flexibility of control, inherent protection against abuse and overloading. For further information get in touch with your nearest Vickers Application Engineering office.

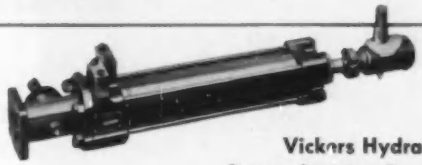
Vickers Pump for Hydraulic Power Steering

This pump is vane type, hydraulically balanced, and has automatic wear compensation. Series VT4 has integral volume control and relief valves and oil reservoir.



Vickers Pumps (Single and Double)

Balanced vane type pumps that automatically maintain optimum radial and axial running clearances over complete pressure range and throughout pump life. The result is long life and maintained high efficiency.

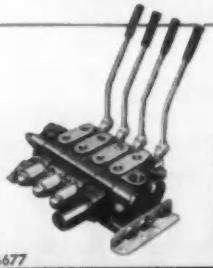


Vickers Hydraulic Power Steering Booster

Provides effortless, positive and shockless steering. With the touch of only a finger, driver can steer the heaviest vehicle on or off the road. Fatigue is reduced and driver efficiency increased.

Vickers Hydraulic Motors

Balanced vane type with exclusive "rocking beam" construction and automatic wear compensation. Variable horsepower (constant torque) characteristics; reversible and can be stalled under load without damage.



Vickers Multiple Unit Valves

Assemblies of standard interchangeable sections provide any desired combination of directional control functions. Exclusive porting arrangement provides smooth and selective inching control and accurate positioning.

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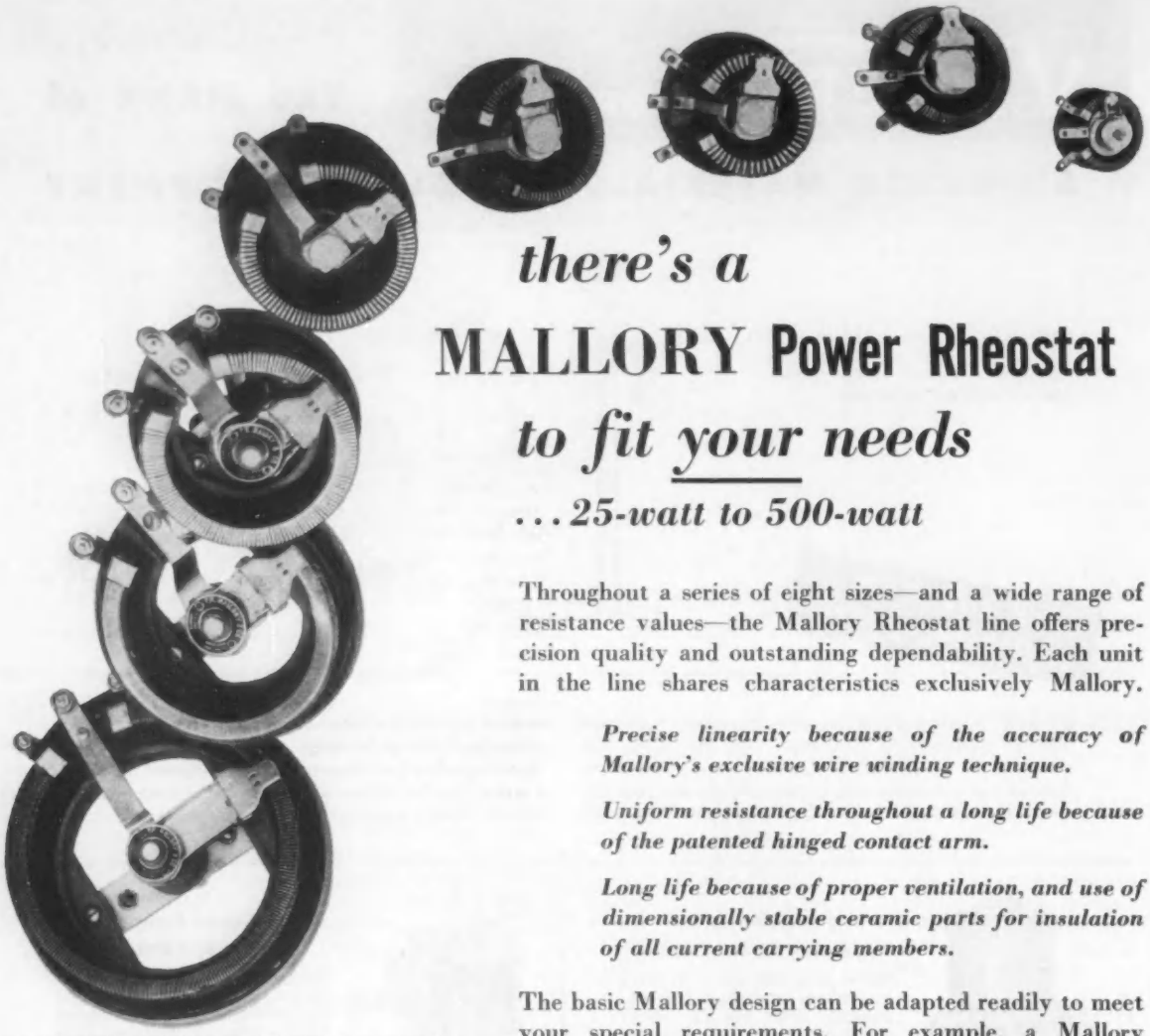
ENGINEERS AND BUILDERS OF OIL HYDRAULIC EQUIPMENT SINCE 1921



there's a
MALLORY Power Rheostat
to fit your needs
. . . 25-watt to 500-watt

Throughout a series of eight sizes—and a wide range of resistance values—the Mallory Rheostat line offers precision quality and outstanding dependability. Each unit in the line shares characteristics exclusively Mallory.

Precise linearity because of the accuracy of Mallory's exclusive wire winding technique.

Uniform resistance throughout a long life because of the patented hinged contact arm.

Long life because of proper ventilation, and use of dimensionally stable ceramic parts for insulation of all current carrying members.

The basic Mallory design can be adapted readily to meet your special requirements. For example, a Mallory variable pitch winding technique produces special tapers with a single wire . . . thus avoiding hot spots and breaks which are common when wires of several sizes are used. Mallory Engineers are ready to meet your needs.

Send today for the complete new catalog of Mallory Power Rheostats and Vitreous Enamel Resistors. It details complete mechanical and electrical specifications.

HERE IS AN IMPORTANT FEATURE . . . THE HINGED CONTACT ARM

It permits cleaning or replacement of the brush without disturbing contact pressure.

Different spring tensions are available to suit the wire size and requirements of each application.

The tension spring carries no current. There is no possibility of annealing during overloads.

Shaft torque is controlled by a *separate* spring. It can be selected to fit your exact needs without effect on contact pressure.

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a "lubrication fitting" that out-thinks a man...

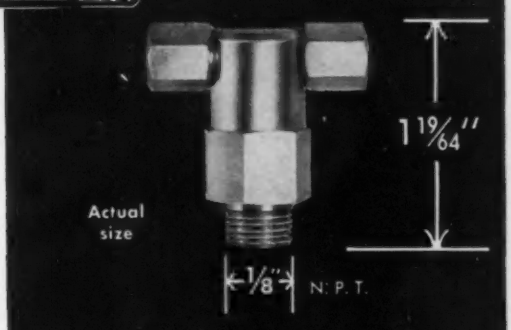
ALEMITE Accumeter®

The low-cost, simple way for you to design fool-proof, automatic lubrication into a machine with many small bearings

Many small bearings on a compact, high-speed machine. You know that proper, exact lubrication is essential, but you also know how crowded the bearings will be. You know that they will be difficult or impossible to reach with grease gun or oil can and that some of them will be missed—and the shutdown time for lubrication will be costly.

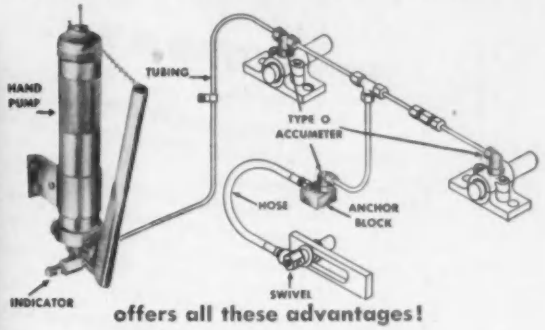
The answer? Alemite Accumeter, the valve that never forgets. This tiny, accurate, and very simple valve automatically meters an *exact* amount of lubricant to the bearing, at exactly the right time, *while the machine is in operation!* Time, maintenance and production costs drop—output soars! That's the reason that better than 95% of all major plants buying machine tools specify centralized lubrication.

Alemite Accumeter Systems are simple and economical to design into any machine—and there is a system perfect for any machine lubrication problem. Find out about these automatic systems now. See for yourself the savings and efficiency they bring to your designs and you too will specify automatic Accumeter.



Type O Accumeter Valves

Meters .005 cubic inch of oil to rotary, oscillating, stationary—plain or anti-friction bearings. Up to 200 small bearings can be served by the single-line system equipped with these fixed output valves. Requires only 3/16" approximate turning radius.



offers all these advantages!

- Eliminates shutdown time for lubrication. Adds productive time to machine output
- Seals completely against dirt, grit, water all the way from "Barrel-to-bearing"
- Prevents bearing troubles due to neglect or use of wrong lubricant
- Services all bearings—including those inaccessible or dangerous—in one operation
- Avoids work spoilage and bearing repairs due to over-lubrication

factory tested—field proved

Exhaustive, in-the-field tests show no appreciable variation in the amount of lubricant discharged after 73,312 lubrication cycles—*equal to* 122 YEARS *of twice-a-day service!*

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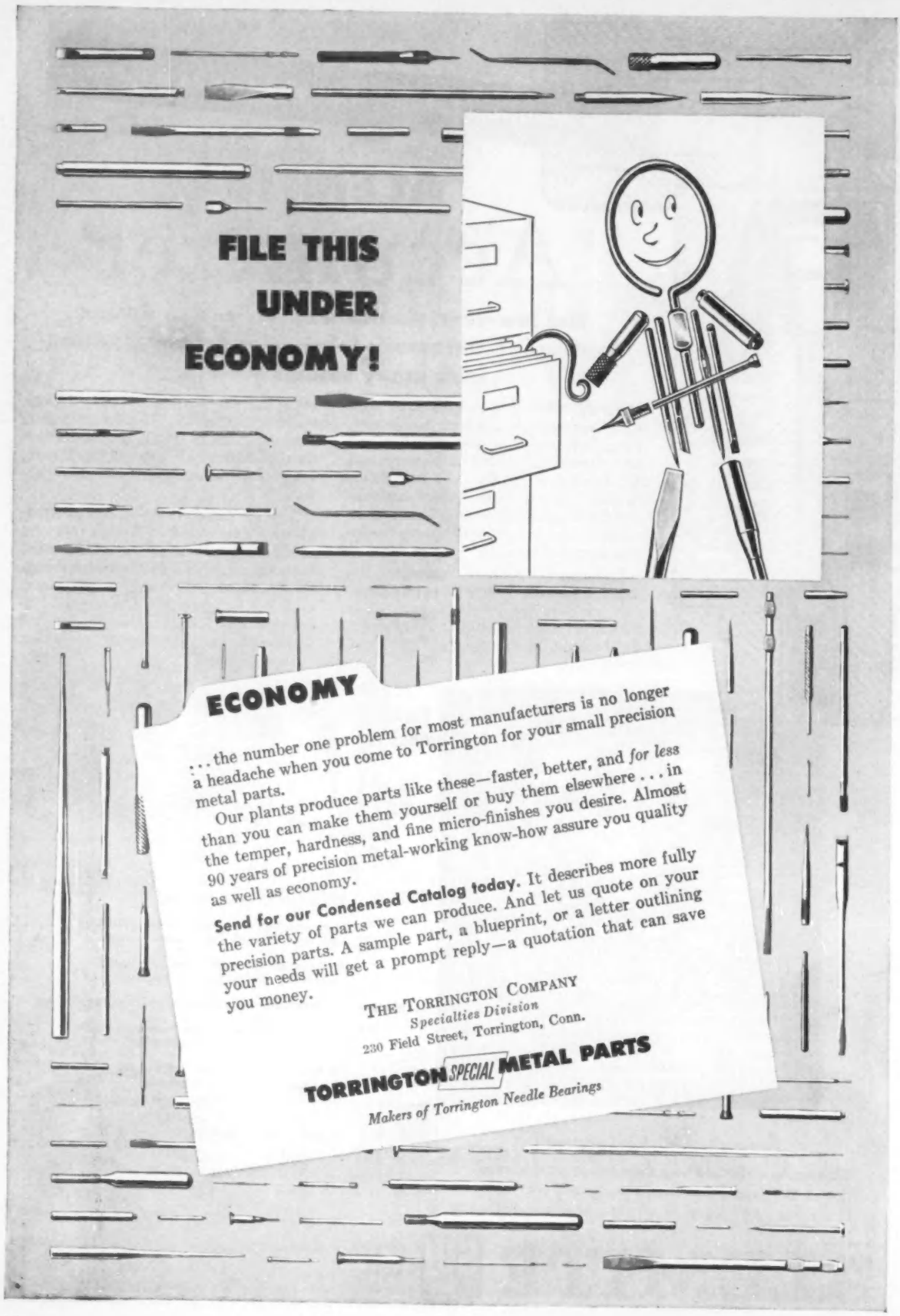

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Send for our Condensed Catalog today. It describes more fully the variety of parts we can produce. And let us quote on your precision parts. A sample part, a blueprint, or a letter outlining your needs will get a prompt reply—a quotation that can save you money.

THE TORRINGTON COMPANY
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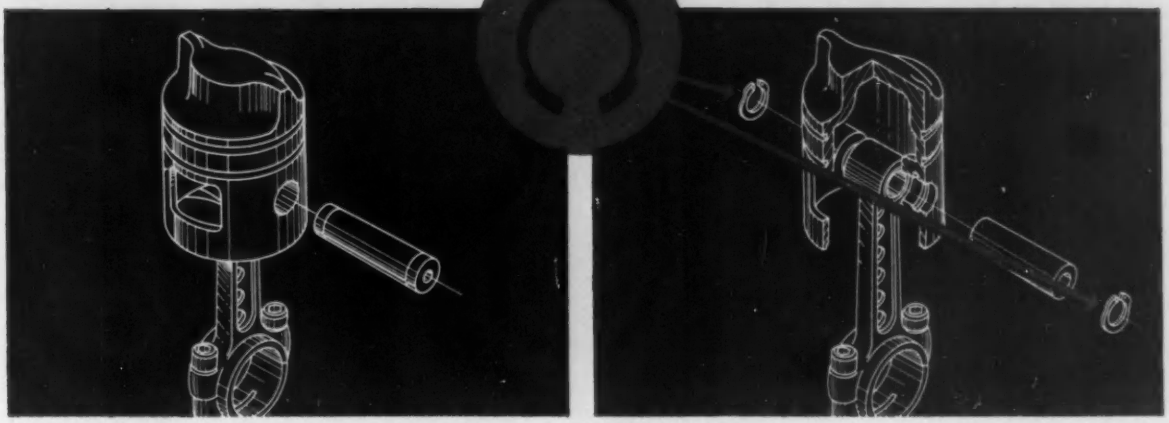
TORRINGTON *SPECIAL* **METAL PARTS**

Makers of Torrington Needle Bearings

2 Waldes Truarc Rings Replace 2 End Plugs ...Eliminate 3 Operations...Save $.066 Per Unit



OLD WAY Two inserted-plug type wrist pin locks hold wrist pin in place. 3 operations involved: costly machining, pressing in place, post-assembly machining. Costly maintenance problem—resulting from end plugs hammering loose.

TRUARC WAY Two Truarc Inverted Retaining Rings (Series 5008) hold wrist pin in place. Truarc Rings snap into grooves easily cut in piston, provide positive lock . . . practically eliminate maintenance costs. Quick assembly, disassembly.

Titan Chain Saws, Inc., Seattle, Washington, uses 2 Waldes Truarc Rings to replace old-style inserted-plug type wrist pin locks in their Titan chain saws. Use of Waldes Truarc Retaining Rings eliminates 2 press fit end plugs. Machining of plugs, pressing in place, finish machining—no longer required. Truarc way holds rejections to a minimum. Unit efficiency is greatly increased.

Redesign with Truarc Rings and you, too, will cut costs. Wherever you use machined shoulders, bolts, snap rings, cotter pins, there's a Waldes Truarc Retaining Ring designed to do a better job of holding parts together.

Waldes Truarc Rings are precision-engineered . . . quick and easy to assemble and disassemble. Always circular to give a never-failing grip. They can be used over and over again.

Find out what Waldes Truarc Retaining Rings can do for you. Send your blueprints to Waldes Truarc engineers for individual attention, without obligation.

USE OF 2 WALDES TRUARC RINGS PERMITTED THESE SAVINGS PER UNIT:

OLD WAY	
Cost of 2 end plugs Cost of pressing in and machining	$ .169
TRUARC WAY	
Cost of grooving piston Cost of 2 Truarc Rings	.103
Saving per Unit	**$ .066**

For precision internal grooving and undercutting... Waldes Truarc Internal Grooving Tool.

Visit the Truarc Exhibit at the I.R.E. Show, Booth 746, MARCH 22-25

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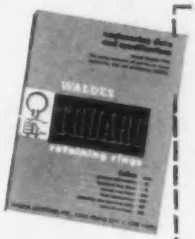

WALDES KOHINOOR, INC., LONG ISLAND CITY 1, NEW YORK

WALDES TRUARC RETAINING RINGS AND PLIERS ARE PROTECTED BY ONE OR MORE OF THE FOLLOWING U. S. PATENTS: 2,382,947; 2,382,948; 2,414,052; 2,420,921; 2,420,341; 2,439,795; 2,441,846; 2,455,163; 2,483,380; 2,483,383; 2,487,003; 2,487,003; 2,491,308; 2,509,081 AND OTHER PATENTS PENDING.

Waldes Kohinoor, Inc., 47-16 Austel Place, L. I. C. 1, N. Y.

Please send me the new Waldes Truarc Retaining Ring catalog. PN036

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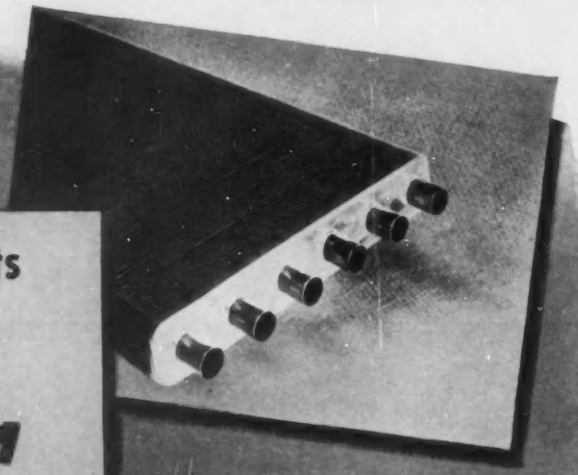
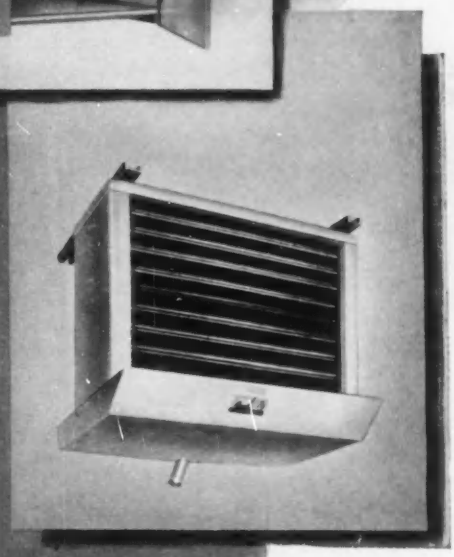
Cut Production Costs with REVERE ALUMINUM



Fin stock, made of Revere Aluminum Coiled Sheet, is saving time and money for leading manufacturers of convectors, baseboard convectors, unit heaters, air conditioners and refrigeration equipment—much of it in combination with Revere Copper Tube. Uniformity of properties and accuracy of gage are among the reasons for the widespread use of this fine Revere material.

Available in a number of alloys, Revere Aluminum Products include coiled sheet, extruded products, seamless tube, and forgings, as well as electrical bar. The Revere Technical Advisory Service is ready to help you use them to advantage.

Send for your free copy of the new 28-page booklet, "Revere Aluminum Extruded Products." Address Dept. PT-3.



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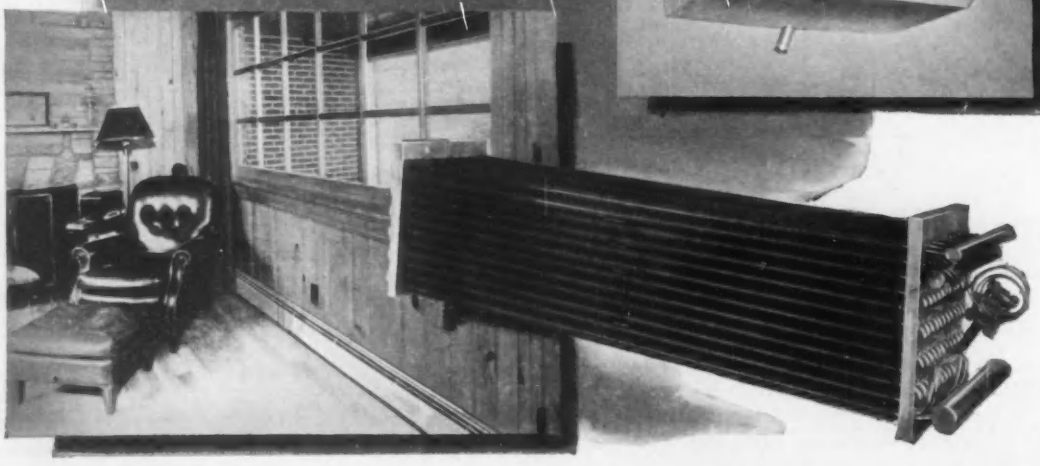

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Better Things for Better Living ... through Chemistry

PRODUCT ENGINEERING NEWS

PROPERTY AND APPLICATION DATA ON THESE VERSATILE PLASTIC MATERIALS: DU PONT NYLON, "ALATHON," "TEFLON," "LUCITE."

NO. 1 — 1954

Bearings of Du Pont Nylon Extend Service Life of Heavy-Duty Hinges

This important improvement in hinge design features smooth-working, non-lubricated bearings of Du Pont nylon

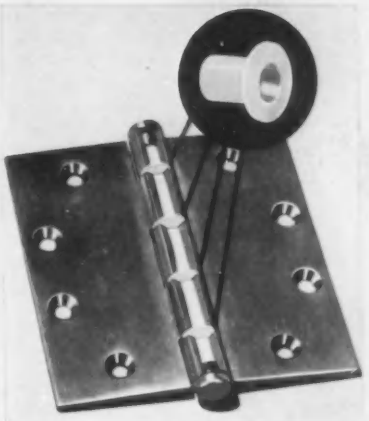
The use of hinge bearings of Du Pont nylon is perhaps the most important development in hinge design in many years. The hinge barrel is streamlined, more compact, wears longer, and there's no squeak . . . and no need for lubrication.

HINGE BEARINGS of Du Pont nylon offer advantages in production and maintenance as well as operation. Initial cost? Low. Production process? Rapid and economical, by injection molding. Maintenance costs drop because these nylon bearings wear longer and never need oiling.

Du Pont nylon is an ideal radial and thrust-bearing material, according to H. S. Getty Co., Philadelphia, Pa., who pioneered the manufacture of the nylon hinge bearing. The nylon bearing provides longer service life; even when hinges are slightly misaligned or are clogged with dirt, the resiliency of nylon prevents binding or stiff operation.

When door hinges with bearings of Du Pont nylon were installed on the doors of one busy department store, the maintenance man said, "If these last six months—they're good!" That was a year and six months ago, and the bearings are still proving their value.

A manufacturer of steel casement doors found that he could use a better, smaller hinge (by one-third) when he used hinges with abrasion-resistant nylon bearings. And he saved money by doing so.



Heavy-duty hinge, manufactured by H. S. Getty Co., utilizes bearings of Du Pont nylon. Nylon bearings increase service life, need no lubrication. Bearings are molded by H. M. S. Associates, Willow Grove, Pa.

Wide use of this hinge bearing is anticipated in public buildings of all types. The marine field may also find good use for these hinges, whose bearings of Du Pont nylon never corrode and do not have to be lubricated.

The use of Du Pont nylon for hinge bearings is only one example of how this Du Pont engineering material makes better product designs possible. For more information, clip the coupon on the other side of this page.

Properties of "Lucite" can help engineers solve design problems

"Lucite" acrylic resin General-Purpose Molding Powder combines moderate heat resistance with ease of injection molding.

▶ *Mechanical Properties:*

Tensile strength at 73°F: 9,000 psi; at 170°F: 4,300 psi. Modulus of elasticity at 77°F: 400,000 psi. Shear strength: 9,000 psi.

▶ *Thermal Properties:*

Deformation under load is 1.15% at 122°F and 1000 lb/sq. in. by ASTM Test D621-48T; heat distortion temperature is 167°F at 264 lb/sq. in. by ASTM Test D648-45T.

▶ *Electrical Properties:*

Dielectric strength, short-time: 400 v/mil. Dielectric constant, 60 cycles: 3.9; 10^6 cycles: 2.9. Power factor, 60 cycles: 0.042; 10^6 cycles: 0.025.

▶ *Optical Properties:*

"Lucite" transmits up to 92% of incident light. Refractive index: 1.49. Clarity not visibly affected by age or weather.

▶ *Chemical Properties:*

Dilute solutions of strong acids (like battery acids) or alkalies do not attack "Lucite." Nor will dilute alcohols, aliphatic hydrocarbons, and petroleum oils.

▶ *Weathering Properties:*

"Lucite" does not craze or lose transparency after long outdoor exposure. Colorless "Lucite" is unaffected by sunlight.

▶ *Miscellaneous Properties:*

Specific Gravity: 1.18. Moisture resistance: excellent. Strength and toughness not affected by water vapor or water immersion. "Lucite" is slow-burning and is ignited only with difficulty. "Lucite" can be worked with standard machine tools, and can be readily joined by heat-welding or cementing.

These properties of Du Pont "Lucite" make it useful in many industries, including automotive, architectural and lighting.

54 parts of Du Pont nylon in new fare box

AFTER 10,000,000 cycles—equal to more than 30 years' actual operation—a cam made of Du Pont nylon was working efficiently under accelerated testing. This proved that nylon was the special engineering material the engineering staff of Grant Money Meters Company, Providence, R. I., was seeking.

Nylon's unique properties fit all requirements so well that nylon was finally specified for 54 key parts. Nylon's lightness of weight helps reduce inertia, promotes accurate operation of ratchet controls. Nylon's low

OVER

DU PONT

PRODUCT ENGINEERING NEWS

PROPERTY AND APPLICATION DATA ON THESE VERSATILE PLASTIC MATERIALS: DU PONT NYLON, "ALATHON," "TEFLON," "LUCITE."

NO. 1 — 1954

54 Fare Box Parts (continued)

coefficient of friction provides quiet, long-lasting operation of bearings, gears, and cams without lubrication. Nylon's durability and strength in thin sections encourage its use in molding of small and intricate shapes.

The use of nylon permits simplified design and often saves steps in manufacturing and assembly. Rapid injection molding with nylon affords savings in time and production costs and, at the same time, provides parts with superior properties.

Fare Box Parts of Du Pont Nylon Include:

Investigate Du Pont plastic engineering materials in your product development programs

ONE OF the family of these versatile engineering materials is often a key factor in product improvement or new product design.

The wide range of properties available with "Alathon"* polyethylene resin, "Lucite"* acrylic resin, "Teflon"* tetrafluoroethylene resin, and Du Pont nylon are helping solve industrial design problems in all industries.

NEED MORE INFORMATION? Clip the coupon for additional data on the properties and applications of Du Pont plastic engineering materials.

Dielectric properties of "Teflon" aid designers of miniature circuits

MINIATURE circuits can develop high temperatures, which, combined with an increased electrical load, may result in the failure of tiny parts. The problems of insulating components of miniaturized circuits were investigated by Microdot Division, Felts Corporation, S. Pasadena, California, in conjunction with their development of a complete line of miniature coaxial connectors and assemblies.

The material which Microdot needed for the connectors and primary wire insulators had to have superior dielectric properties and heat resistance. Durability and resistance to moisture were also essential.

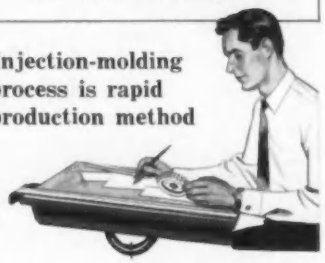
Coaxial connectors and cable are insulated with Du Pont "Teflon." These miniature-circuit parts are made by Microdot Division of Felts Corp.

Du Pont "Teflon" tetrafluoroethylene resin was chosen after extensive tests. "Teflon" is an excellent insulator. It has a dielectric constant of 2.0, and a power factor of less than 0.05% at frequencies as high as 30,000 megacycles. The dielectric properties of "Teflon" remain constant at temperatures from −80°F to 500°F. Exposure to arc leaves no carbonized path. "Teflon" absorbs no water by ASTM Test D570-42.

Where resistance to high temperatures, good dielectric properties, and durability are needed, Du Pont "Teflon" has proved its versatility.

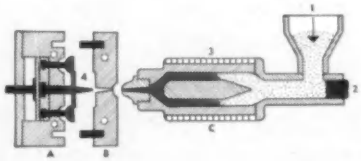
POINTERS ON PROCESSING OF DU PONT POLYMERS

Injection-molding process is rapid production method



INJECTION molding is one process for producing large quantities of plastic parts. A typical injection-molding assembly, shown in the diagram, operates as follows:

Parts marked *A* and *B* close and lock to form the *mold;* they move to contact part *C* which contains molten plastic. Measured quantities of the granulated plastic (*1*) are fed into the machine. The reciprocating *ram* (*2*) forces this material into the *heating chamber* (*3*), where the powder liquefies. Each forward motion of the ram (*2*) forces molten plastic into the closed mold (*A* plus *B*) where the plastic solidifies, and forms the *molded part* (*4*). Then the mold opens as shown in the diagram and the plastic part is ejected. In the meantime, the ram moves back, allowing more powder to feed into the machine, preparing it for another cycle.



The production rate depends on a number of variables, including the size of the part and the number of identical cavities cut into the mold. If molded parts are small, dozens of them can be made at one shot, whereas large parts may be produced one at a time. Cycles of 1 or 2 moldings a minute are not uncommon.

Here are some of the advantages of injection molding:

1. High rate of production.
2. Economical production in quantity.
3. Little or no finishing cost.
4. Parts molded to close tolerances.

E. I. DU PONT DE NEMOURS & CO. (Inc.) POLYCHEMICALS DEPARTMENT
Room 103, Du Pont Bldg., Wilmington 98, Del.

Please send me more information on the Du Pont plastic engineering materials checked: ☐ *Du Pont Nylon* ☐ *"Alathon"* ☐ *"Teflon"* ☐ *"Lucite." I am interested in evaluating these materials for* _____

NAME _____ POSITION _____

COMPANY _____

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CITY _____ STATE _____

TYPE OF BUSINESS _____

*"Alathon," "Lucite," "Teflon" are registered trade-marks of E. I. du Pont de Nemours & Co. (Inc.)

Need compact bearings for long service?

here's how leading makers of small gasoline engines get them with NEEDLE BEARINGS

America's best known manufacturers of small gasoline engines specify Torrington Needle Bearings because of their compactness, high capacity and long maintenance-free operation.

Needle Bearings have been *performance-proved* in every type of small two-cycle and four-cycle engine such as those on power mowers, generators, chain saws, materials handling equipment, pumps, compressors and many other types of equipment.

As main bearings on crankshafts, on connecting rods at crankpin and wristpin ends, on reduction units, governing mechanisms, crankshaft counter-balances and camshafts, Needle Bearings, compact in size themselves, contribute toward keeping engine size and resulting weight down. Simultaneously, their ability to retain lubricants for long periods boosts power output and prolongs engine life.

Torrington Needle Bearings have become "standard equipment" throughout industry since their introduction nearly twenty years ago. Wherever high capacity is needed in small space, Needle Bearings can offer superior performance.

The Needle Bearing may be the solution to your anti-friction problems. Why not let our engineers help you find out?

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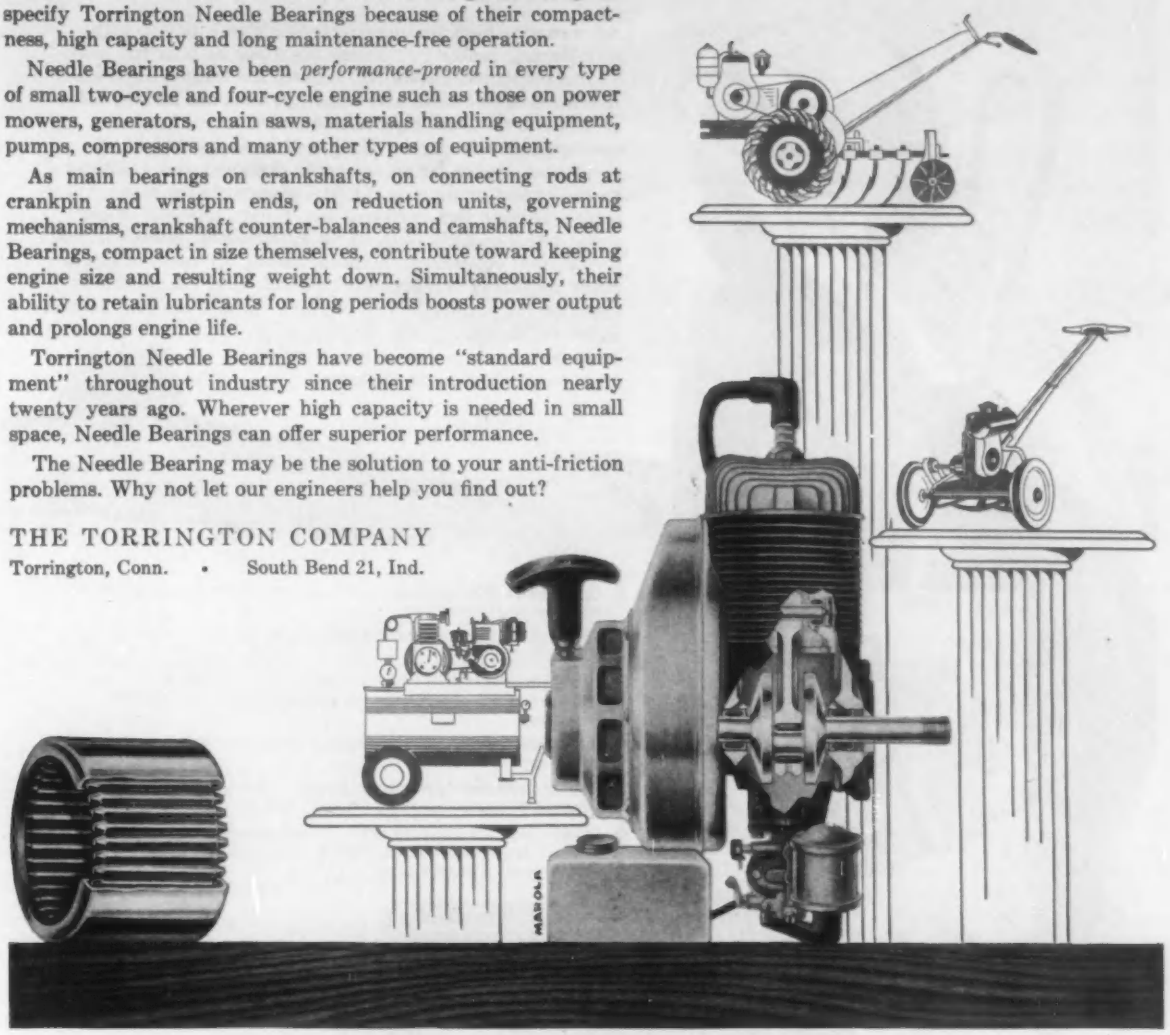

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Trade-marks of leading manufacturers of small gasoline engines who use Needle Bearings.

It beat the heat of the SAHARA

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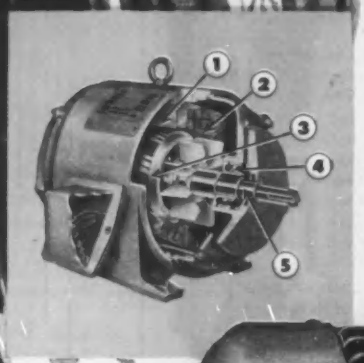
Abnormally high temperatures can wreak havoc with any electric motor . . . unless it's *made* to beat the heat. World-respected Brook AC motors are built with mica-insulated stator slots and windings that are impregnated and baked to resist high temperature conditions encountered here in the U. S. and in every corner of the world. Every Brook motor is designed and *precision built* to meet or *surpass* NEMA standards for size, rating, service and performance. Easily serviced in *any* shop; parts quickly obtainable everywhere. Ideally suited for original equipment manufacturers, for users of equipment requiring replacement motors, and for products destined for export to any country. Whatever *your* needs, insist on Brook . . . the world's *most respected* motor— built by the world's *most experienced* manufacturer.



1. **Ceramic-coated stator laminations** provide excellent dielectric qualities and maximum resistance to heat.
2. **Stator slots insulated with mica-coated fabric**—highly resistant to water, oil, heat and electrical strain.
3. **Dynamically-balanced rotors** to eliminate vibration . . . a practically indestructible unit of pure copper or aluminum passing through rotor laminations.
4. **U. S. standard interchangeable ball bearings** in metric sizes. Mountings protected against dirt and moisture.
5. **Precision-ground shaft**—painstakingly ground to the highest, most exacting standards. Made of the finest, high-tensile steel.
6. **All major types**—available from stock . . . open drip-proof, splash-proof, totally enclosed non-ventilated, totally enclosed externally fan-cooled . . . in a wide range of horsepower sizes.

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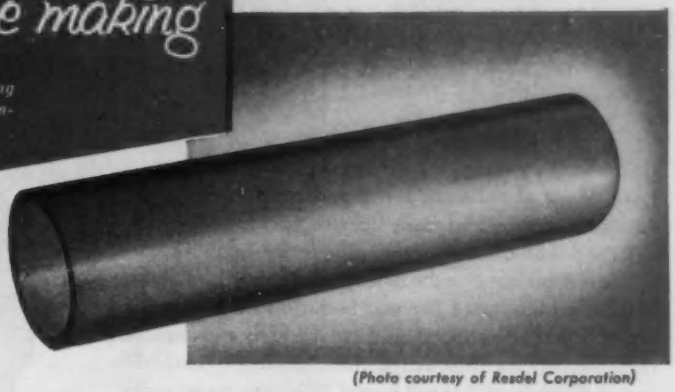
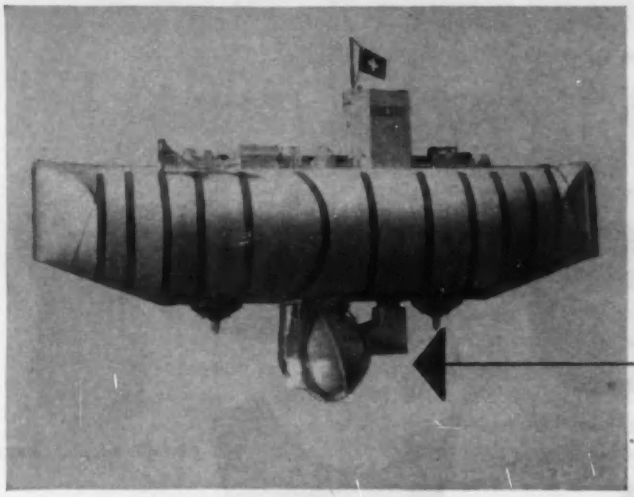


(Photo courtesy of Resdel Corporation)

ARALDITE RESINS USED TO MAKE CENTRIFUGAL CAST PIPE WITH EXCEPTIONAL PROPERTIES

Araldite Resins of the "CN" series are formulated especially for casting, potting, impregnating and encapsulating uses. The pipe shown here is available in a wide range of gauges, diameters and lengths. In addition to exceptional toughness, impact and dielectric strength, it offers excellent resistance to chemical attack from circulating corrosive liquids. Araldite cast pipe of larger diameters with sealed ends is used for storage of chemicals as well. The strong clean pipe is also undergoing tests for supportive structural uses. Araldite Resins of this type achieve outstanding results in castings bonded to metal parts, impregnating of transformers, capacitators, coils, motor windings and other electrical apparatus.



POWER CABLE INSTALLATION PROBLEM SOLVED EFFECTIVELY WITH ARALDITE RESINS IN "BATHYSPHERE" FOR RECORD-SHATTERING DESCENT

On this newest "Bathysphere" the controls are connected by instrument and power cables which pass through the wall of the cabin to the apparatus located outside the cabin. In the previous "Bathysphere" all motors were controlled through relay circuits. The relays were installed outside the cabin and only small wires were able to pass through the walls. By sealing the openings with Araldite Resins it became possible to simplify the arrangement and put full-sized power cables carrying currents up to 200 amperes through the walls. The Araldite Resin used was simply poured into the space between the walls of the sphere and the cables, where it hardened and formed a seal capable of withstanding the tremendous pressure of the water at the great depth of more than 4,000 meters below the surface of the Mediterranean to which the "Bathysphere" recently descended.

SEND THIS COUPON...or write us on your company letterhead... for complete technical data on the physical properties and recommended procedures for the successful use of Araldite Resins for your fabricating needs.

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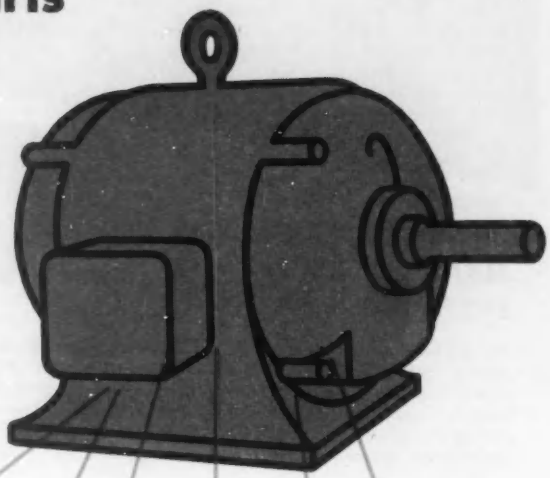
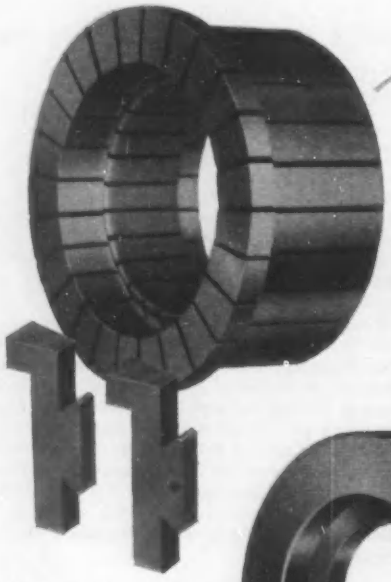
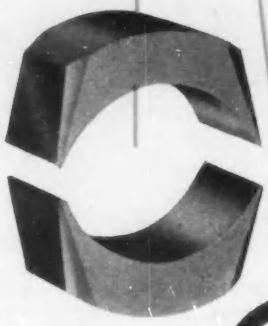




GRAMIX commutator segments

GRAMIX bearings



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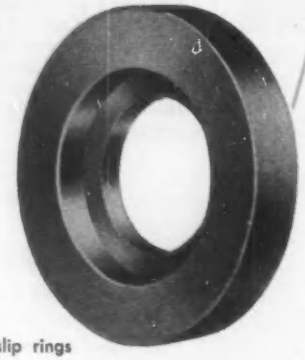

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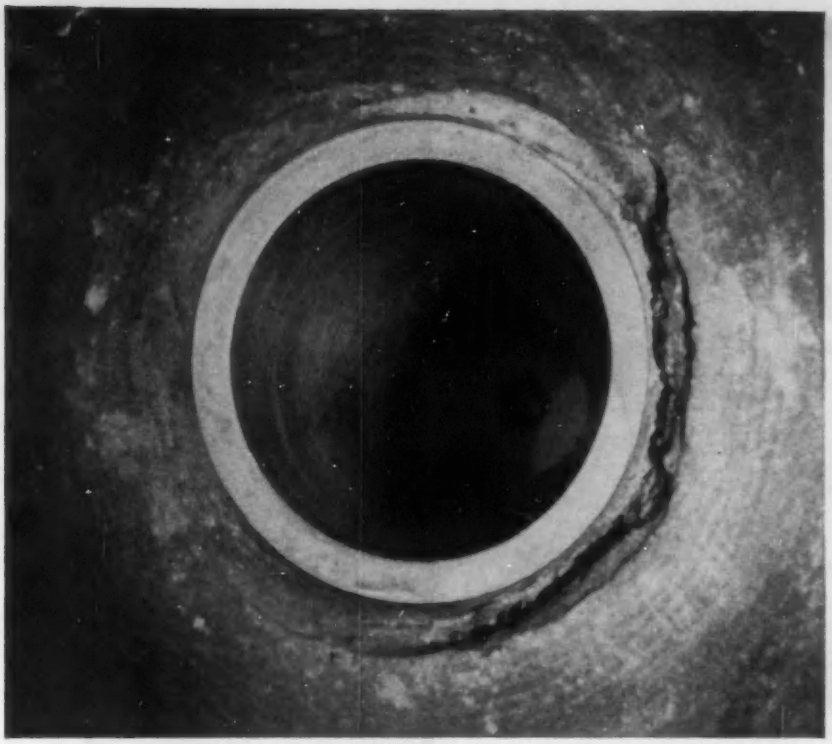

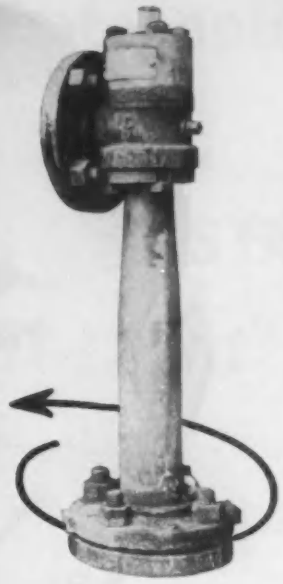

STILL NO SIGN OF CORROSION on the titanium diffuser of this steam jet ejector despite 1½ years' exposure to dilute hydrochloric acid! Note how acid has eaten away the cast-iron flange of the diffuser.

Titanium steam jet diffuser outlasts others 10 to 1 under corrosive conditions

A combination of corrosive chemical vapors and high-velocity steam proved too much for ordinary steam jet diffusers in service at a Du Pont Pigments Plant. Biting hydrochloric acid formed in the line and cut the service life of cast iron diffusers to less than 3 months. Diffusers of bronze and other corrosion-resistant alloys were then tried with little improvement.

Finally, a diffuser of titanium was fabricated and installed. It's still on the job after a period of over 1½ years of uninterrupted service—*ten times the average service life of other diffusers!* Inspection reveals no sign of wear or corrosion on the diffuser, thanks to the excellent corrosion resistance of titanium.

Corrosion resistance is only one of the many advantages of titanium and titanium alloys. Made from titanium sponge—pioneered commercially by Du Pont—these new structural materials have very high strength-to-weight ratios and greater ability to stand elevated temperatures than aluminum or magnesium.

Begin planning now to improve your products with titanium and be prepared for the day when it is available for expanded civilian use. As a pioneer in the field we can help you with valuable information on properties, applications and processing of this new metal. We invite your inquiry for more information.

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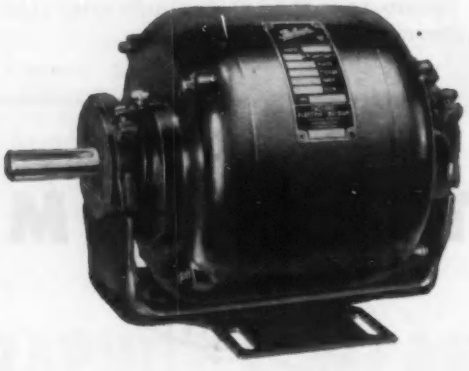

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NEW DRI-STAT "Bright-Light" paper offers, for the first time, office photocopying that truly deserves the name. Developed by Peerless Photo Products, Inc., DRI-STAT "Bright-Light" paper allows you to make sharp, clear, black-and-white photocopies of any original, under the normal levels of illumination in today's modern offices . . . fluorescent or incandescent light of fairly high intensity, or subdued daylight. Here, at last, is a paper that will give you good results under four to five times more light than you could ever work in before.

Now you can really make full use of transfer-process photocopying . . . the modern, quick, inexpensive method of making exact copies of anything written, drawn, or printed . . . anywhere in your office. No longer need you put up with the inconvenience of having to locate your photocopy equipment in an out-of-the-way corner, a stuffy closet or a crowded stockroom. When you use the new DRI-STAT "Bright-Light" paper, you can put your photocopy equipment right where you want it . . . right where it's most convenient and comfortable to use . . and get sparkling, clear, black-and-white copies, regardless of room illumination.

DRI-STAT papers give these amazing results not only on DRI-STAT equipment, but with almost every other type of transfer-process photocopying equipment now on the market. If you already have such equipment, try DRI-STAT papers and see the improvement!

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You can copy originals up to 11″ by 17″ in size on DRI-STAT equipment, or continuous strip matter up to 12″ wide. Results are equally good from opaque or translucent originals, since copying can be done either by the reflex or the contact method.

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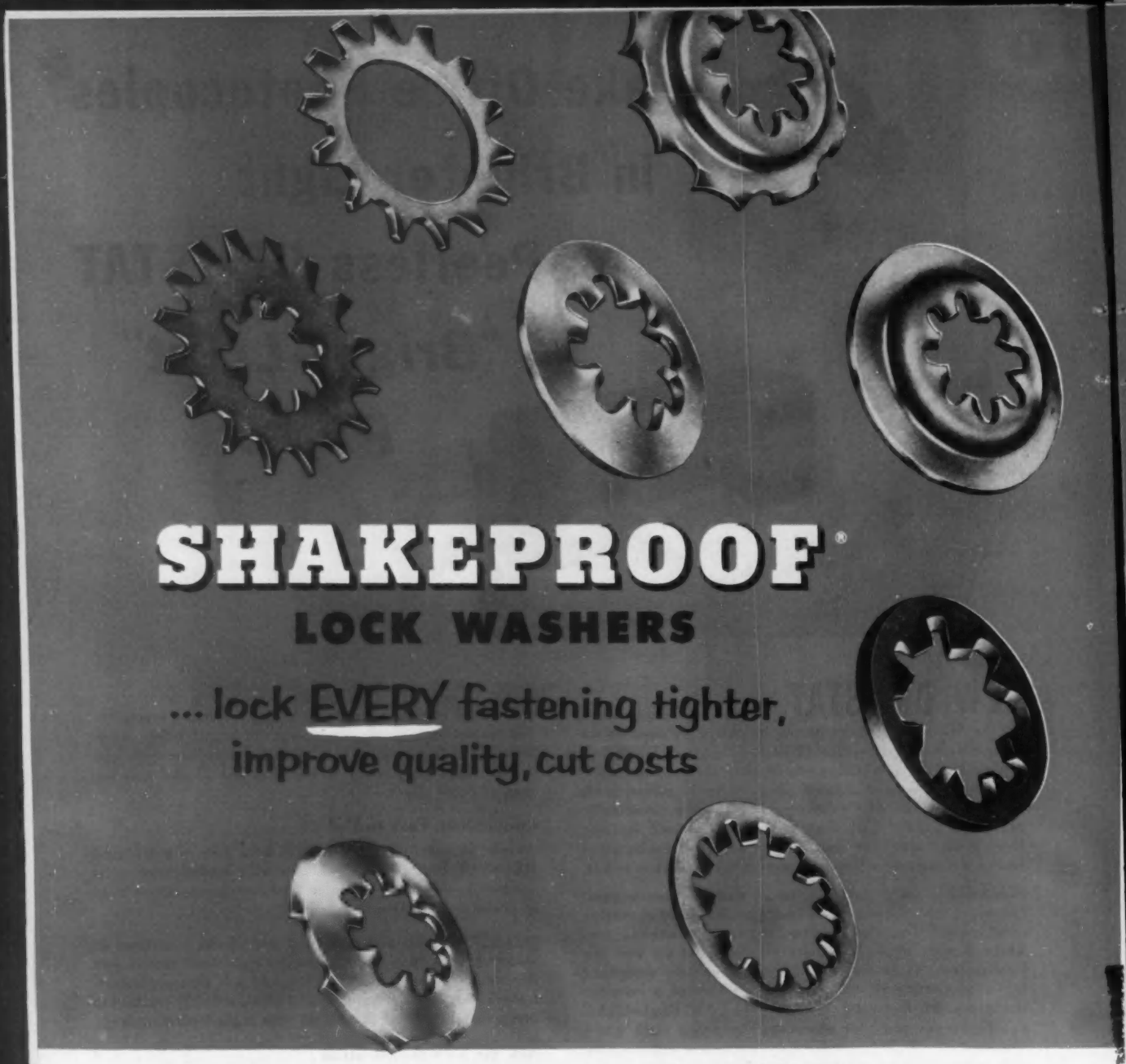

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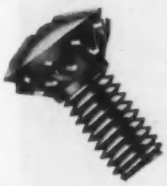


All Shakeproof® Lock Washers can be pre-assembled with screws to eliminate separate washer handling . . . and reduce costs! You're certain to improve quality, too, because the lock washer can't be omitted.

KEPS®

Shakeproof also developed pre-assembled nuts and lock washers. They are fast, easy to use, always lock tight. With KEPS, every fastening is protected against vibration loosening.

FREE testing sample kit

Test Shakeproof Lock Washers on your own products . . . right in your own product laboratories. See how they lock even tighter as vibration increases; improve quality . . . and cut costs in your assembly. Send for your kit now.

new...

Soreng "Standard" Solenoids Deliver Unmatched Quality— Save Money!

Occasionally, manufacturers have requested a particular modification of a Soreng solenoid design on unusually short notice. Because, in the past, we carried no finished solenoid stocks, we were sometimes unable to fill such orders. However, the new Soreng "Standard" Solenoid alleviates this problem.

How The "Standard" Meets Your Specifications

The four basic solenoid types shown here provide twelve sets of characteristics. When you give us the specifications of your design, our engineers can quickly recommend the combination of type, duty and voltage necessary to do the job.

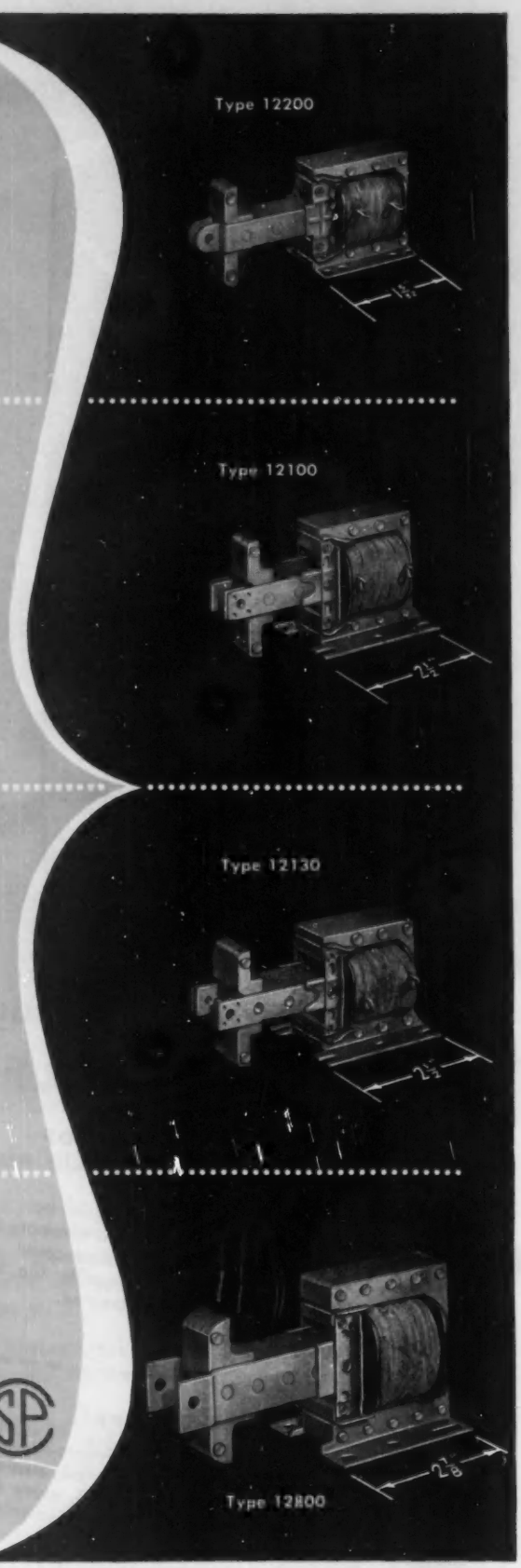
The standard units have all the exclusive features of any Soreng custom designed solenoid . . . more pull where needed, double shading coils, quiet operation, retained uniform characteristics, and a life equal to the product in which they are used.

How The "Standard" Saves Money

Of course, savings are always possible through standardization. And, in this particular case, the savings are two-fold. First, rising costs have been minimized so that first cost is held down. Secondly, with little or no lead time required, you can lower your investment in a parts inventory.

This gives you some idea of the tremendous possibilities of the Soreng Standard Solenoid. For more complete information, power curves, dimensions and electrical characteristics, write for Bulletin CF-124.

Bulletin CF-124
Drawings, Power Curves, Technical Data



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A PRINCIPLE OF GOOD DESIGN

You don't have to choose between PRECISION and RELIABILITY

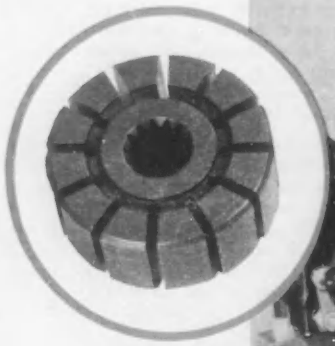
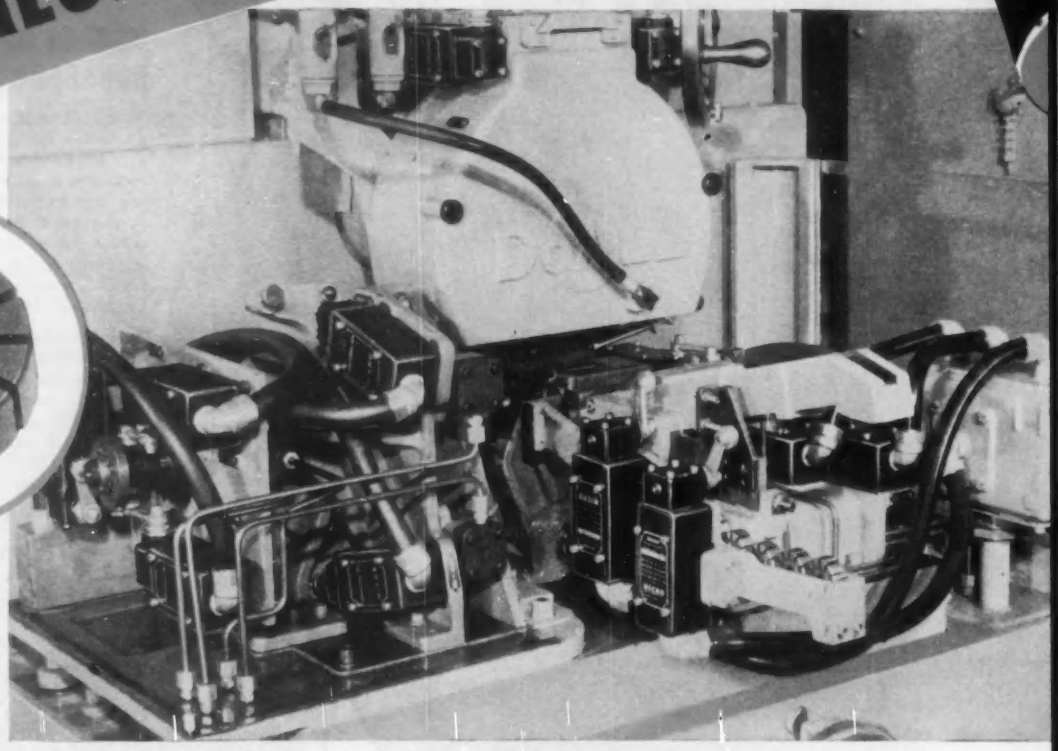


Illustration of small rotor part whose slots are finished-ground automatically



Open view of DoALL Automatic Grinder showing 11 of 17 MICRO SWITCH limit switches which control the grinding cycle

Switches operate over 57,000 times a day for precise control of DoALL Automatic Grinder

Seventeen MICRO SWITCH heavy duty limit switches were selected by engineers of the DoALL Company for use on this automatic grinder. This machine finish grinds 12 slots in a small rotor part at the rate of 40 rotors per hour.

MICRO SWITCH precision switches were chosen for this exacting duty for:

LONG LIFE: Some switches operate every 1½ seconds, three shifts a day—over 57,000 operations each 24 hours.

PRECISION: Switches repeat exact operating point through millions of precise operations.

PROTECTION: Switches are well-housed and protected against effects of oil splash, dirt and dust.

VERSATILITY: Switches are easily adjustable to meet varied types of actuation and for mounting in cramped quarters.

Three actuation types of "ML" switches are used. Some roller arm switches are actuated from a shaft which has both longitudinal and rotational motion. Others are actuated by horizontal slide motion, by cams against roller and by straight plunger motion.

The use of these switches is typical of the ability of MICRO SWITCH engineering to provide the exact precision switch for the job. Whatever your requirement there is a MICRO SWITCH precision switch to meet it. Call a field engineer at any of 16 branch offices to help you select the switch for your application.

MICRO SWITCH
A DIVISION OF MINNEAPOLIS-HONEYWELL REGULATOR COMPANY
FREEPORT, ILLINOIS

MICRO SWITCH heavy duty limit switches give you BOTH

MICRO SWITCH provides a complete line of extremely reliable, small-size, high-capacity, snap-action precision switches. Available in a wide variety of sizes, shapes, weights, actuators and electrical characteristics. For all types of electrical controls.

Available in rugged housings . . . sealed or explosion-proof. Adjustable to almost every type of mounting or actuation

• MICRO SWITCH "ML" and "ML-E" (explosion-proof) heavy duty limit switches offer design engineers an ideal combination of rugged long life and utmost operating precision.

Roller arm actuated switches are field adjustable to any of four positions—adjustable to 870 positive lock positions through 360°. Roller plunger actuator may be rotated 90°.

Explosion-proof switches (light covers above) are Underwriters' listed for hazardous atmospheres, Class I, Groups C & D.

Pilot duty rating for both the heavy duty and the explosion-proof switches is 125 volts a-c, 6 amperes normal, 60 amperes inrush; 250 volts a-c, 3 amperes normal, 30 amperes inrush; 480 volts a-c, 1.5 amperes normal, 15 amperes inrush; 600 volts a-c, 1.2 amperes normal, 12 amperes inrush.

For full information on MICRO SWITCH heavy duty limit switches or the complete line of MICRO SWITCH precision switches, you are invited to contact your nearest branch office.

"We considered aluminum tube . . ."

"First of all, we wanted to save weight in this new product. We did it with aluminum.

"Second, we had a corrosion problem. That called for copper.

"And, third, we had to make our unit smaller. That meant we had to use a finned tube."

"That looks like a tough proposition. How did you make out?"

"Well, we found a product combining all three characteristics—called Wolverine Trufin*. They have one type—bi-metal—an integral finned aluminum tube with a choice of copper-base alloy liners. Now that we've tried it, we won't use anything else!"

"Just a minute. What do you mean—integral?"

"That means that the fins are part of the tube. They're extruded—literally squeezed—right out of the wall of the tube. Incidentally, because of the integral feature, the fins are unaffected by sudden temperature changes or vibration. And—remember—Trufin provides maximum heat transfer."

"Maybe we can use it too?"

"Probably. Wolverine has a Trufin data sheet which tells you all you need to know about sizes, fin heights and fin spacings. It tells you, too, about other types of Trufin—those made of all aluminum, all copper or all copper-base alloys, electric-welded steel or other metals."

Add it up: If you want to save space and weight—guard against corrosion from light hydrocarbons—boost efficiency and knock down the cost of your heat exchanger — the answer's at Wolverine. Write for data today!

WOLVERINE TUBE DIVISION
of CALUMET & HECLA, INC.

ESTABLISHED 1916

Manufacturers of Quality-Controlled Tubing

1479 CENTRAL AVENUE • DETROIT 9, MICHIGAN

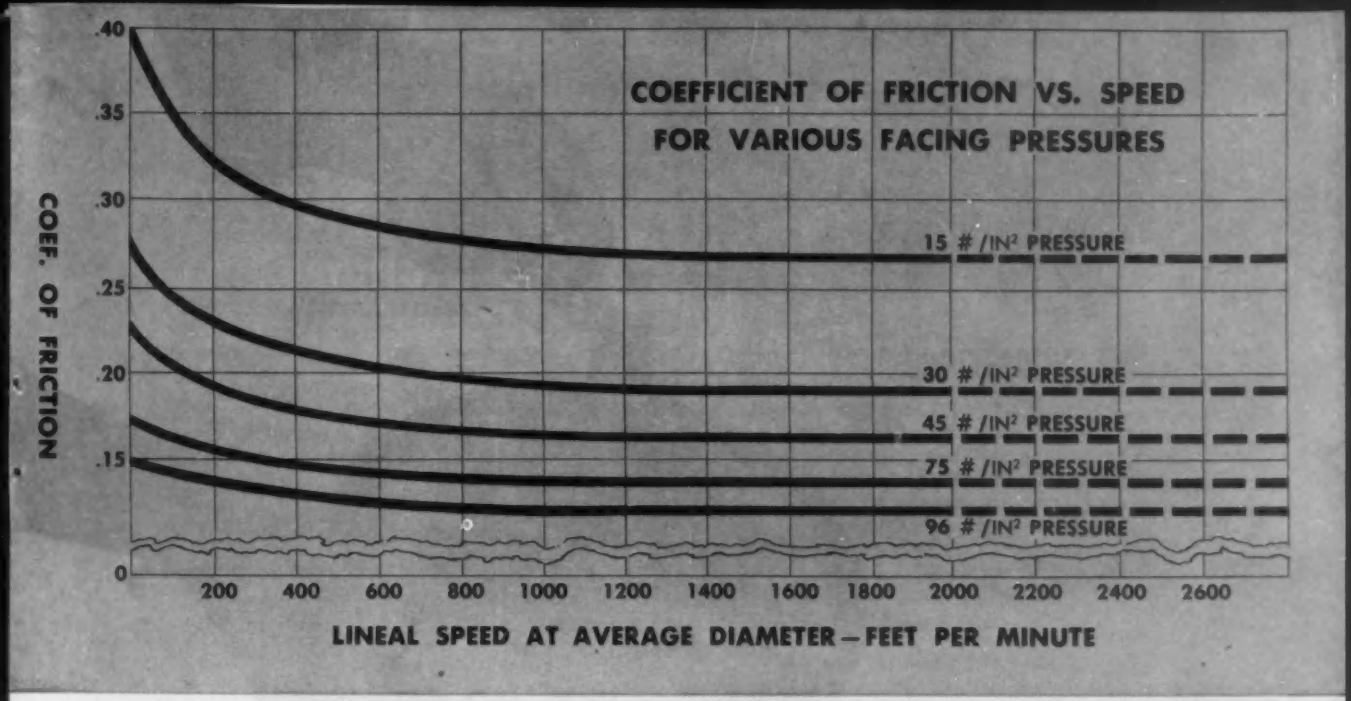
Plants in Detroit, Mich. & Decatur, Ala. *Sales offices in Principal Cities*

EXPORT DEPT., 13 E. 40th ST., NEW YORK 16, N. Y.

†A PATENTED PROCESS RE22465

*REG. U.S. PAT. OFF.

Wolverine Trufin® and the Wolverine Spun End Process† available in Canada through the Unifin Tube Co., London, Ontario



Curves show how a typical cork-compounded facing delivers high coefficient of friction under engagement pressures from 15-96 psi. Test facing, run in oil on steel plate, is similar to that shown in photo below. Cork's high coefficient of friction helps the clutch designer reduce size, weight, and costs.

CORK CLUTCH FACINGS:

High torque capacity at low engagement pressures

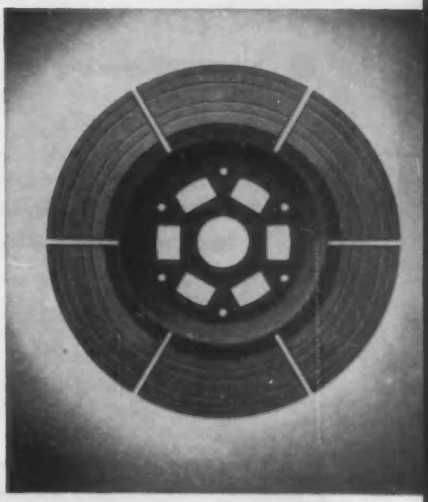
The ability of cork-compounded facings to work efficiently without excessively high engagement pressures has helped many clutch manufacturers get high torque capacity at low cost—and at the same time reduce wear and improve engagement.

In automotive transmissions, for example, various cork plates are used under unit pressures of 45 psi to about 150 psi with excellent results. In some of these transmissions, the ambient oil temperature during operation is in the neighborhood of 300° F.

In both wet and dry clutches, Armstrong facings of cork composition, cork-and-rubber, or cork-fiber give highly efficient performance with economy. Cork is inherently a low-cost material, and its resilience eliminates the need for grinding in after the facing has been bonded to the plate. In addition, cork provides so much torque capacity it often enables you to reduce the number of plates needed, reduce their size, or cut down on engagement pressure.

Perhaps the most surprising thing about cork is how long it lasts. Because a cork facing is soft and resilient, you might think it would wear rapidly. Armstrong-compounded facings in the automatic transmissions of ten different automobiles prove the contrary: they last for the life of the car with a minimum of service and replacement.

Most conventional clutches, and many unusual designs, can get economically efficient performance from one of Armstrong's many facing materials. If you'd like to know more about cork facings, or if you have a new clutch design that might benefit from a cork facing, get in touch with Armstrong today. Write Armstrong Cork Company, Friction Materials Department, 7203 Irvin Street, Lancaster, Pennsylvania.



This Armstrong facing is typical of those used in automobile fluid clutches at engagement pressures of 45-150 psi. Armstrong's friction materials are used in many varying types of applications, from tractors to sewing machines.

ARMSTRONG'S FRICTION MATERIALS

we "threw away the book" to make this die casting...

● Thin walls blending into heavy sections made this a tough one . . .
but **Stewart** turns out castings like this in volume

After 44 years, Stewart Die Casting is still young enough to have new ideas. When conventional methods are not good enough, we "throw away the book" and find a way. Whatever type of die castings you need – small or large, simple or intricate – count on *Stewart* to meet your most rigid specifications . . . on time.

SERVICES AVAILABLE . . .

Designing • Engineering • Die Making
Metallurgical Control • Most Modern Die Casting Equipment • Complete Machining, Polishing and Assembly Facilities.

44 years of helping industry to "Make It Better"

Stewart DIE CASTING

. . . a division of STEWART SW WARNER

CHICAGO, ILLINOIS, 4535 FULLERTON AVENUE • BRIDGEPORT, CONNECTICUT, 275 WARREN STREET

ALLIS-CHALMERS

PUMPS for Designers

3 Ways to Save

SAVE ENGINEERING TIME

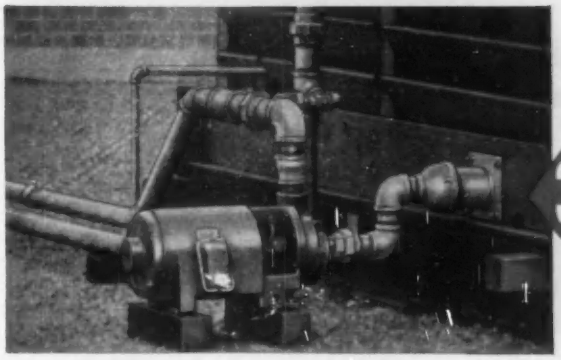
1

Allis-Chalmers representative will sit down with you in the planning stage and help you design the best possible pump set-up at the lowest cost. A-C field engineers will save you much costly engineering work and *guarantee* the complete pump and motor unit.

SAVE—NO EXTRA PARTS TO BUY

Designed as a complete, compact unit, Allis-Chalmers close-coupled pumps don't require extras — such as couplings, bases or shims. The pumps come as units ready to hook up and run!

2



3

SAVE ON INSTALLATION TIME

Bolt it down, hook up the line and piping, and your Allis-Chalmers pump is ready to go. There's no alignment problem. Correct installation is a big factor in pump performance and the A-C engineer will advise you at this point.

For more information about Allis-Chalmers designers' pumps, write for bulletins 52B6140, 52B7529, 52B6083 or 52B6975.

ALLIS-CHALMERS, Milwaukee 1, Wisconsin

FHP PACKAGE PUMP

Standard with mechanical seal. Widely used and accepted for air conditioning and refrigeration.

Bulletin 52B7529

***ELECTRIFUGAL* PUMP**

A close-coupled pump with either conventional packing or mechanical seal.

Bulletin 52B6140

SUPPORTING ADAPTER PUMP

Flange motor and pump on sturdy supporting adapter. With conventional packing or mechanical seal.

Bulletin 52B6083

VERTICAL MOUNTED PUMP

Mechanical seal or sealless units with choice of submerged or sidewall mounting.

Bulletin 52B6975

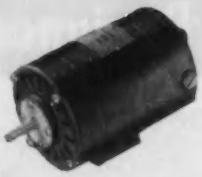
Electrifugal is an Allis-Chalmers trademark.

ALLIS-CHALMERS

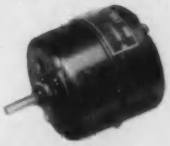
A-C ALLIS-CHALMERS

A-4228

if it's a quantity fractional H.P. motor application

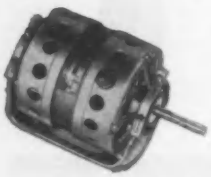


UNIVERSAL & D.C. MOTORS
1/1000 to 1/2 h.p.

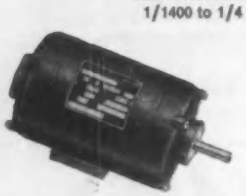


SHADED POLE MOTORS
1/2000 to 1/8 h.p.

CHECK WITH HOWARD TODAY!



INDUCTION MOTORS
1/1400 to 1/4 h.p.



The eight Howard motors illustrated here are representative of the wide range of fractional H. P. motors available at Howard.

Currently Howard fractional H. P. motors are serving many of the leading names in industry in hundreds of applications—accounting machines, fans, beacon lights, coin operated devices, dictating machines, facsimile equipment, air conditioners, projectors, tape recorders, power tools, sewing machines and many more. The wide range of H. P. ratings, motor type, frame sizes, speed and torque, voltage and power supply and other important considerations make Howard motors a likely source for your particular requirements.

If you are using or choosing fractional H. P. motors for your products, write or phone (Racine 2-2731) today. Give us your specifications and we will supply a motor to do your job. Please address Chief Sales Engineer.

DEPT. PE-3 • HOWARD INDUSTRIES, INC. • RACINE, WISCONSIN

DIVISIONS: EMC ELECTRIC MOTOR CORPORATION · CYCLOHM MOTOR CORPORATION · RACINE ELECTRIC PRODUCTS

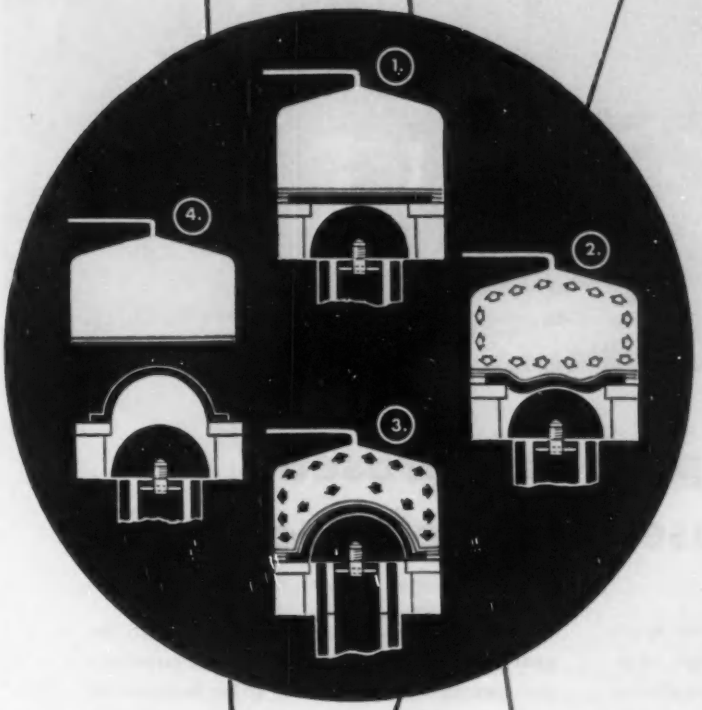
OIL RESISTANCE

FLEXIBILITY

ABRASION RESISTANCE

These properties of neoprene make a better

HYDROFORM MACHINE



A recently developed method of fluid forming is employed in a new metal drawing machine which greatly simplifies production. It's known as "Hydroforming" and depends on a flexible neoprene diaphragm for its effectiveness. Under controlled conditions of pressure from the hydraulic oil in the head, the diaphragm acts as a universal female die . . . cuts die costs 50% or more.

In operation, a metal blank is placed on a draw ring and the upper forming cavity, faced with the neoprene diaphragm, is locked into position (Fig. 1). Hydraulic pressure is increased to a predetermined level—up to 8,000 psi for some metals (Fig. 2). The die punch is then forced up against the diaphragm into the forming cavity, and pressures up to 15,000 psi literally wrap the blank around the punch (Fig. 3). Pressures are then released, the forming cavity is raised, and the punch stripped from the finished part (Fig. 4).

Because of the even distribution of pressure, the draw is uniform with no thin-outs or spot stresses. And with every draw there's new proof of the remarkable resistance of neoprene to deterioration from oil and abrasion. Even after thousands of cycles the rugged diaphragms remain free from cracks . . . retain their resilience. Small wonder so many designers turn to Du Pont neoprene when it can stand up to a test like this!

Properly compounded neoprene will resist:

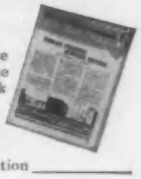
DU PONT
REG. U.S. PAT. OFF.

BETTER THINGS FOR BETTER LIVING . . . *THROUGH CHEMISTRY*

NEOPRENE

The rubber made by Du Pont since 1932

FREE! **THE NEOPRENE NOTEBOOK**



Each issue shows new, unusual applications of neoprene . . . new products . . . improved designs. The neoprene application cited above is covered in detail in Notebook No. 54. Add your name to the mailing list today.

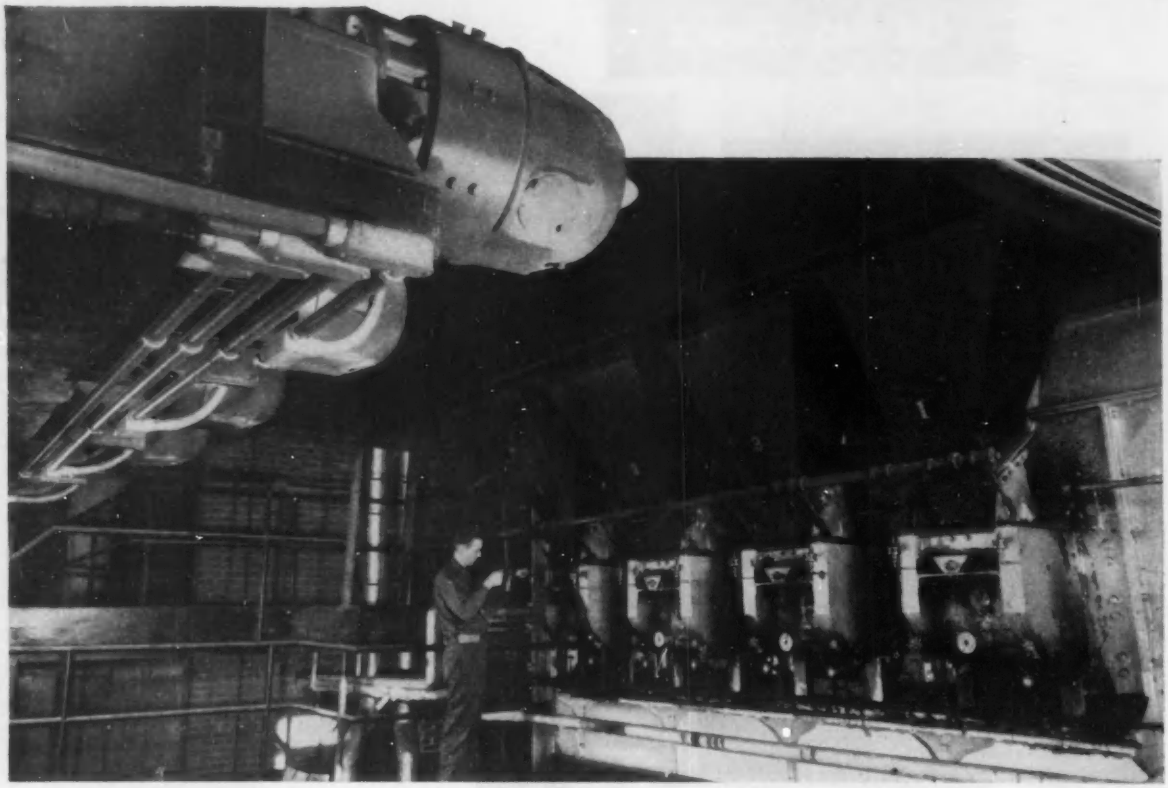
E. I. du Pont de Nemours & Co. (Inc.)
Rubber Chemicals Division PE-3, Wilmington 98, Del.

Name_____ Position _____

Firm_____

Address_____

City_____ State_____



Drive mounting problems erased with Westinghouse *Life-Line** Gearmotors

Putting the best drive in the minimum space is a problem constantly facing design engineers. In answer to this problem, Westinghouse Life-Line Gearmotors provide unit compactness, rugged construction and job-proved efficiency.

Westinghouse Life-Line Gearmotors have both motor and gears designed as an integral unit. As a result, there's a major saving in space because all belts, chains and pulleys can be eliminated. This means no alignment problems. Since integral design lessens the number of wearing parts, over-all maintenance is cut to a minimum.

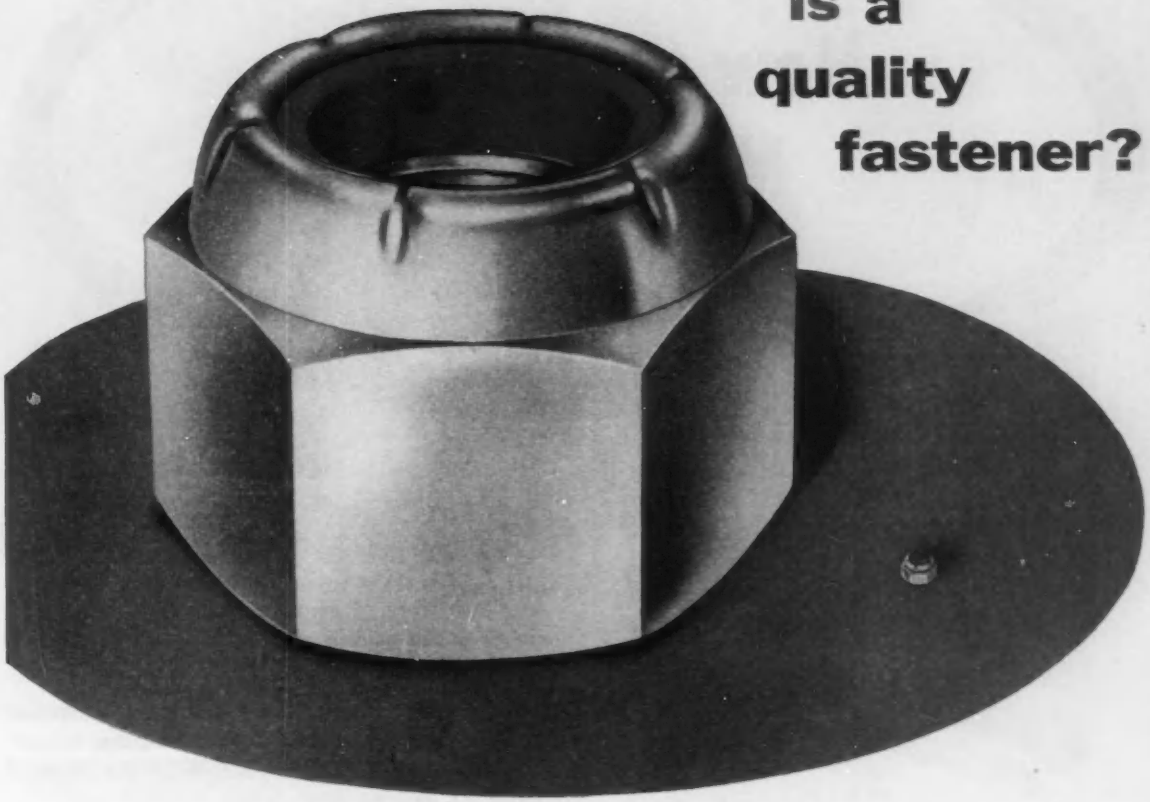
With split-case gearmotors, there's no need to allow large work areas for removal or dismantling—all servicing can be done with the gearmotor "on the job". Split-case construction permits the gear cover to be removed in minutes and makes all working parts readily accessible. Any servicing, therefore, becomes a simple, speedy operation.

Taper-hardened gear teeth, thorough lubrication and industry-tested Life-Line Motors are but a few of the features which assure long, dependable performance from Westinghouse Gearmotors.

Your local Westinghouse Representative will gladly furnish you with additional information. Call him at any time or write Westinghouse Electric Corporation, P. O. Box 868, Pittsburgh 30, Pa. *Trade-Mark J-07322

YOU CAN BE SURE...IF IT'S Westinghouse

What size is a quality fastener?



Here are two ELASTIC STOP® nuts.
Each has the familiar red locking collar. Each is self-locking, vibration-proof and can be reused many times. Each is a fast, readily assembled one-piece unit . . . will maintain accurate adjustment anywhere on a bolt. Each will afford positive protection against thread corrosion . . . prevent liquid seepage along bolts. Each is manufactured in quantity. Each is exactly controlled as to quality of raw material, finished dimensions, class of thread fit, seat squareness and finish. Each has a record for precision and uniformly high performance that is unmatched.

But . . . one measures 1/10 inch across the flats; the other, 4 inches. Between these two, there are more than 530 different hex nuts in the ESNA line. They are the result of variations in height, material, finish and size.

Look to ESNA for the top quality self-locking fastener that fits your need best.

ELASTIC STOP NUT CORPORATION OF AMERICA

ESNA® TRADE MARK

ROLLPIN TRADEMARK

Elastic Stop Nut Corporation of America
Dept. N58-32, 2330 Vauxhall Road, Union, N. J.
Please send the following free fastening information:

☐ ELASTIC STOP nut bulletin

☐ Here is a drawing of our product. What self-locking fastener would you suggest?

Name_____ Title_____

Firm_____

Street_____

City_____ Zone_____ State_____

How to Fabricate More Profits

From 50% rejects to 1%
10c saved per piece
15% to 20% savings
40% rejects before—now 1%
8c to 10c saved per piece
From 20% rejects to none

This is a story of small change that put folding money in the pockets of a half-dozen fabricators of metal products.

The small change is that of specifying Carpenter Stainless Tubing rather than just "stainless tubing" . . . the folding money is attested by the captions under the pictures at the left.

What is more important to you, however, is the fact that none of the orders were for "specials" . . . all of these pieces were made from "mill run" tubing as delivered by Carpenter.

The moral of the story is, of course, that there *is* a difference in Stainless Tubing—and Carpenter makes it. Why not make the most of this *provable* difference in your own shop—for your own profit. Call your nearest Carpenter Distributor for your next order of tubing . . . plus design and engineering help if you need it. "One Call Does It All."

The Carpenter Steel Company, Alloy Tube Division, Union, N.J.
Export Dept.: The Carpenter Steel Co., Port Washington, N.Y.
"CARSTEELCO"

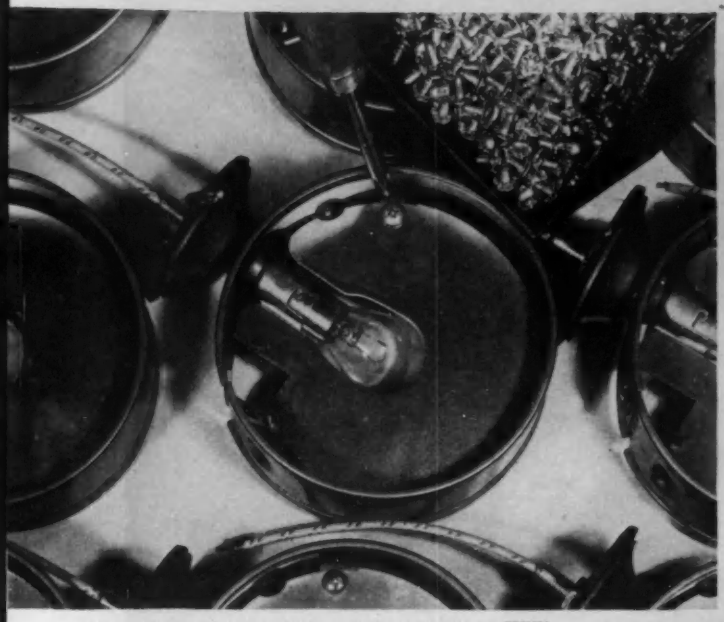
Carpenter

STAINLESS TUBING & PIPE

Analysis — Tolerance — Finish

• guaranteed on every shipment

Users praise Phillips Cross-Recessed-Head Screws



YANKEE METAL PRODUCTS CORPORATION'S William Chickvary, Product Engineer, points out that, "Through constant vibration over all kinds of roads, our units take a terrific beating. We not only need a method of positive tightness *when installed*, but the screw must *stay tight* through prolonged use. We are getting just that from Phillips head screws." Yankee's directional turn light is shown here.

THE FASCO HASSOCK-TYPE AIR CIRCULATOR doubles as a stool and is assembled with an eye to wear. "We try to use Phillips screws wherever possible," says William F. Purves, chief engineer. "They are ideal on power-driving equipment because they are self-centering." Chester Ciscotti, Jr., above, uses Phillips self-tapping screws to fasten bottom cone to legs.

WIREMOLD'S "PLUGMOLD" relies on Phillips screws exclusively to make positive contact between contact point of outlet and electrical conductor supplying power. Jeanie Garrity here inspects tightness of screws. "I can't overemphasize the important job this screw is performing for us," says Eugene Pitcher, plant engineer. If screws work loose after repeated use, the outlet has no power. Phillips screws stay tight.

MANUFACTURERS OF PHILLIPS CROSS-RECESSED-HEAD SCREWS

THE FASTENERS OF TODAY... AND OF THE FUTURE

X marks the spot

... the mark of extra quality

American Screw Company • Atlantic Screw Works, Inc. • The Blake & Johnson Co. • Central Screw Company • Continental Screw Company • The Eagle Lock Company Elco Tool and Screw Corporation • Great Lakes Screw Corporation • The H. M. Harper Co. • The Lamson & Sessions Company • National Lock Company • The National Screw & Manufacturing Co. • Parker-Kalon Div. General American Transportation Corporation • Pheoll Manufacturing Co. • Rockford Screw Products Co. • Scovill Manufacturing Co. • Shakeproof • The Southington Hdwe. Mfg. Company • Sterling Bolt Company • Wales-Beech Corp.

MAYARI R

IS EASY TO WELD

One of the special advantages of Mayari R is that you can weld it by all the usual methods. The development of this high-strength, low-alloy steel closely followed the development of welding itself, and great care was taken to make Mayari R easy to weld. Its low carbon content of .12 max insures maximum weldability.

Whether you weld Mayari R by the electric-resistance, automatic-submerged-arc, electric-arc, or gas-welding process, you can use the same general procedures as you would with ordinary structural steel. No need for special equipment, and good welding speeds can be maintained.

Classed as a non-air-hardening steel, Mayari R shows no appreciable hardening from usual welding temperatures. For the general run of welding operations, no preheat or postheat is required. As with ordinary carbon steels, assemblies or structures subject to fatigue, dynamic stresses or severe impact should be stress-relieved after welding.

If you have some special questions on the welding of Mayari R, let us hear from you. And for your files, you should have our Mayari R Catalog 353. Phone or write the nearest Bethlehem office for a copy.

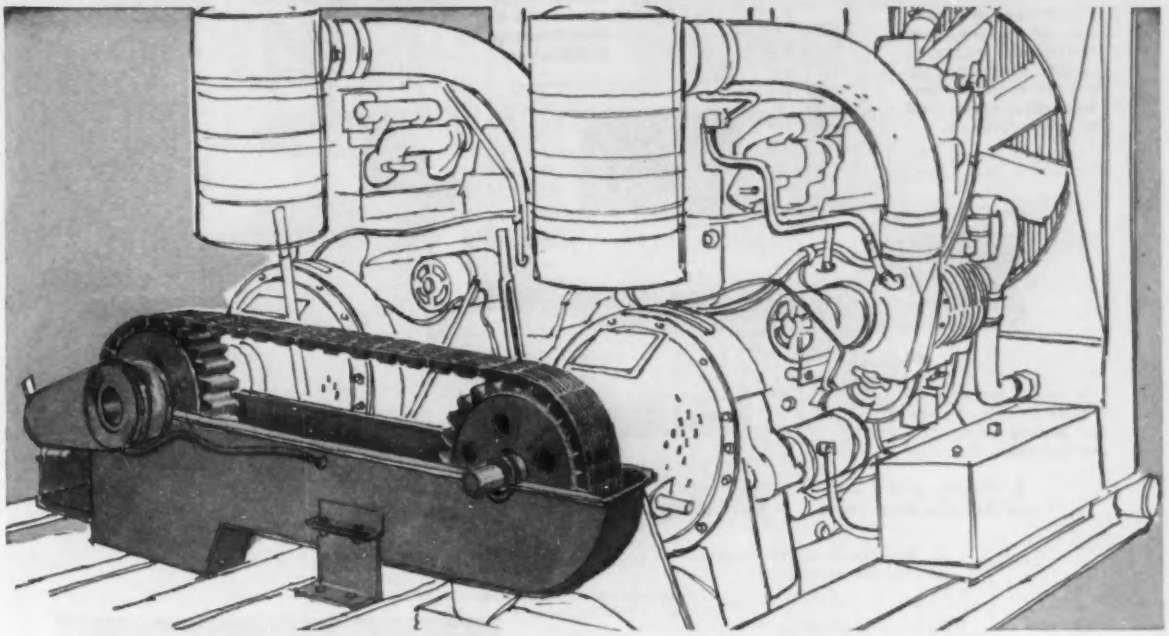
BETHLEHEM STEEL

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation
Export Distributor: Bethlehem Steel Export Corporation

Mayari R *makes it lighter... stronger... longer lasting*

Morse HY-VO DRIVE for a new age in power transmission!



How compounding with HY-VO could save you as much as $4,560

Now, gain new advantages in buying and compounding smaller, higher speed engines with Morse Hy-Vo Drive.

You make major cost savings.

The total cost of two high-speed engines and the Hy-Vo Drives with which they are compounded will usually be considerably less than a single large engine of equivalent horsepower. A brief look at some figures will show how this works . . .

For example, if you needed 250 continuous horsepower at 1200 rpm., you could: 1) Buy a manufacturer's 250 hp., 1200 rpm. engine, which lists for $13,380; 2) buy the 250 hp., 1800 rpm. engine for $11,930 (using Hy-Vo as a connection and reduction drive, also eliminates the costly flexible coupling normally required in choice No. 1); 3) or, use two 130 hp., 1800 rpm. engines, listing for a total of $8,820, and use Hy-Vo as your compounding drive.

With the 250 hp., 1800 rpm. engine, you save $1,450, more than enough to pay for your Hy-Vo Drive. Compounding two 130 hp., 1800 rpm. engines, you save $4,560 over base list cost of the 250 hp., 1200 rpm. engine.

From this saving you could pay for your Hy-Vo Drive and bank several thousand dollars. In most cases, too, Hy-Vo will be so narrow it will eliminate costs of outboard bearings and mountings, with the bonus that single-engine operation is possible under reduced power requirement.

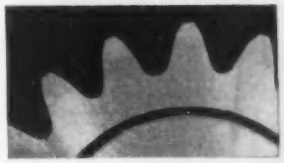
Other power transmission methods generally have either inherent restrictions on rotative speeds and velocities that limit 200 hp. or larger engines to 1200 rpm., or are too costly. Hy-Vo has far greater upper limits, with relatively lower cost.

Because of exceptional rotative speeds and velocities, Hy-Vo brings you comparable savings in electric motors, too. Write us for details on compounding with Morse Hy-Vo Drive.

MORSE CHAIN COMPANY

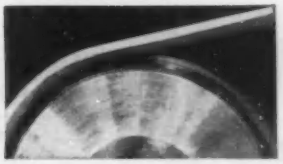
7601 Central Ave. • Detroit 10, Michigan

SOME DESIGN FACTORS BEHIND HY-VO'S SUCCESS . . .



Hy-Vo's many design and manufacturing refinements result in a drive with unusual power transmitting capacity. Note involute tooth design of Hy-Vo Sprockets . . .

. . . and the new, Hy-Vo Compensating Rolling Joint, which always shifts the pitch line automatically as the Hy-Vo Chain engages the involute teeth of the sprocket.

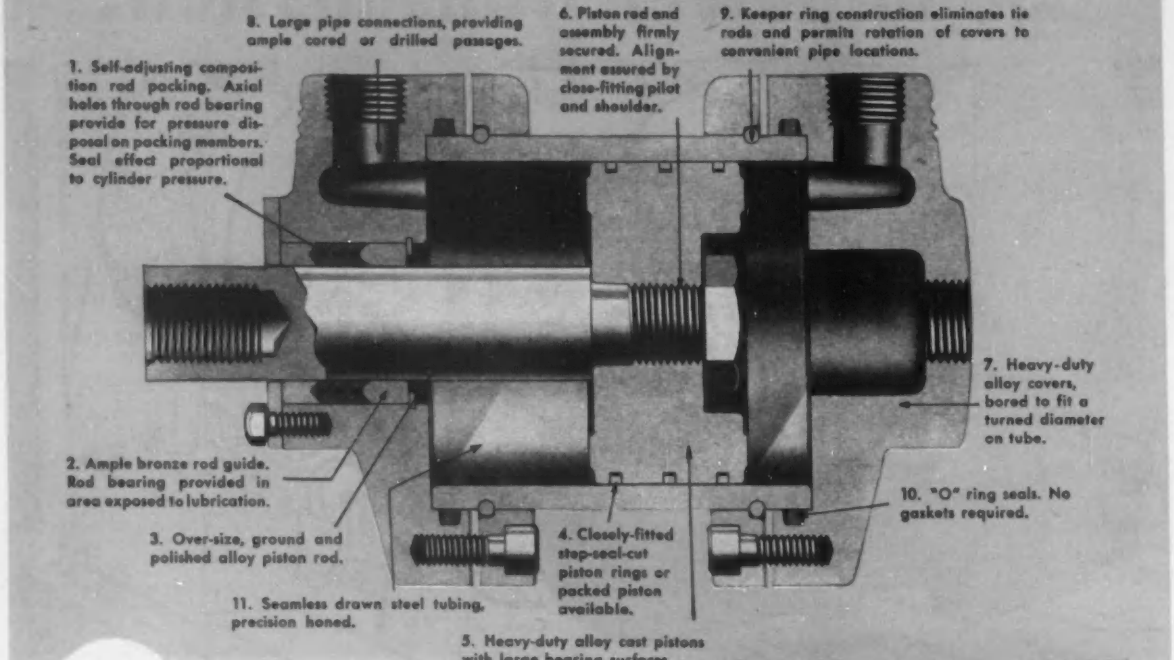


Chain follows a path truly tangent to sprocket pitch circle, virtually eliminating chordal action. A new, balanced link design greatly improves stress distribution.

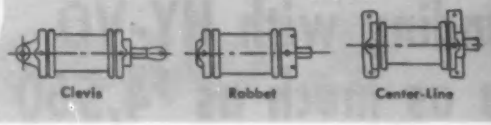
MORSE BW

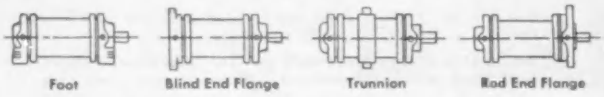
MECHANICAL POWER TRANSMISSION PRODUCTS

More Power to You


8. Large pipe connections, providing ample cored or drilled passages.
6. Piston rod and assembly firmly secured. Alignment assured by close-fitting pilot and shoulder.
9. Keeper ring construction eliminates tie rods and permits rotation of covers to convenient pipe locations.
1. Self-adjusting composition rod packing. Axial holes through rod bearing provide for pressure disposal on packing members. Seal effect proportional to cylinder pressure.
7. Heavy-duty alloy covers, bored to fit a turned diameter on tube.
2. Ample bronze rod guide. Rod bearing provided in area exposed to lubrication.
10. "O" ring seals. No gaskets required.
3. Over-size, ground and polished alloy piston rod.
4. Closely-fitted step-seal-cut piston rings or packed piston available.
11. Seamless drawn steel tubing, precision honed.
5. Heavy-duty alloy cast pistons with large bearing surfaces.

SEVEN STANDARD MOUNTINGS





..with RIVETT HYDRAULIC CYLINDERS

You'll find the performance of Rivett hydraulic cylinders close to foolproof. Designed with the utmost simplicity, they have no tie rods — keeper ring design permits covers to be rotated to convenient pipe connections and installation made in a minimum of space. External "O" rings are used as static seals to eliminate gaskets and assure leakproof operation. Sealing efficiency improves with increased pressure. Closely fitted automotive type piston rings reduce friction to a minimum.

Available in three pressure ranges: to 300 P.S.I. maximum and 1500 P.S.I. maximum service with standard models. 3000 P.S.I. maximum and higher services furnished on application. Seven standard mountings, in 10 bore diameters, in any stroke up to 96", with standard size or 2:1 over-size piston rods, cushioned rod end, blind end or both. Special covers supplied. Send for Catalog Section 106.

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the best running mate your product can have

Millions of Delco Motors—fractionals and integrals—are giving reliable service in the operation of farm equipment, home appliances, tools and machinery of every sort.

Such wide usage suggests that Delco Motors give a good account of themselves, performance-wise. Such user acceptance suggests, too, that you would find a Delco Motor the best running mate for *your* product.

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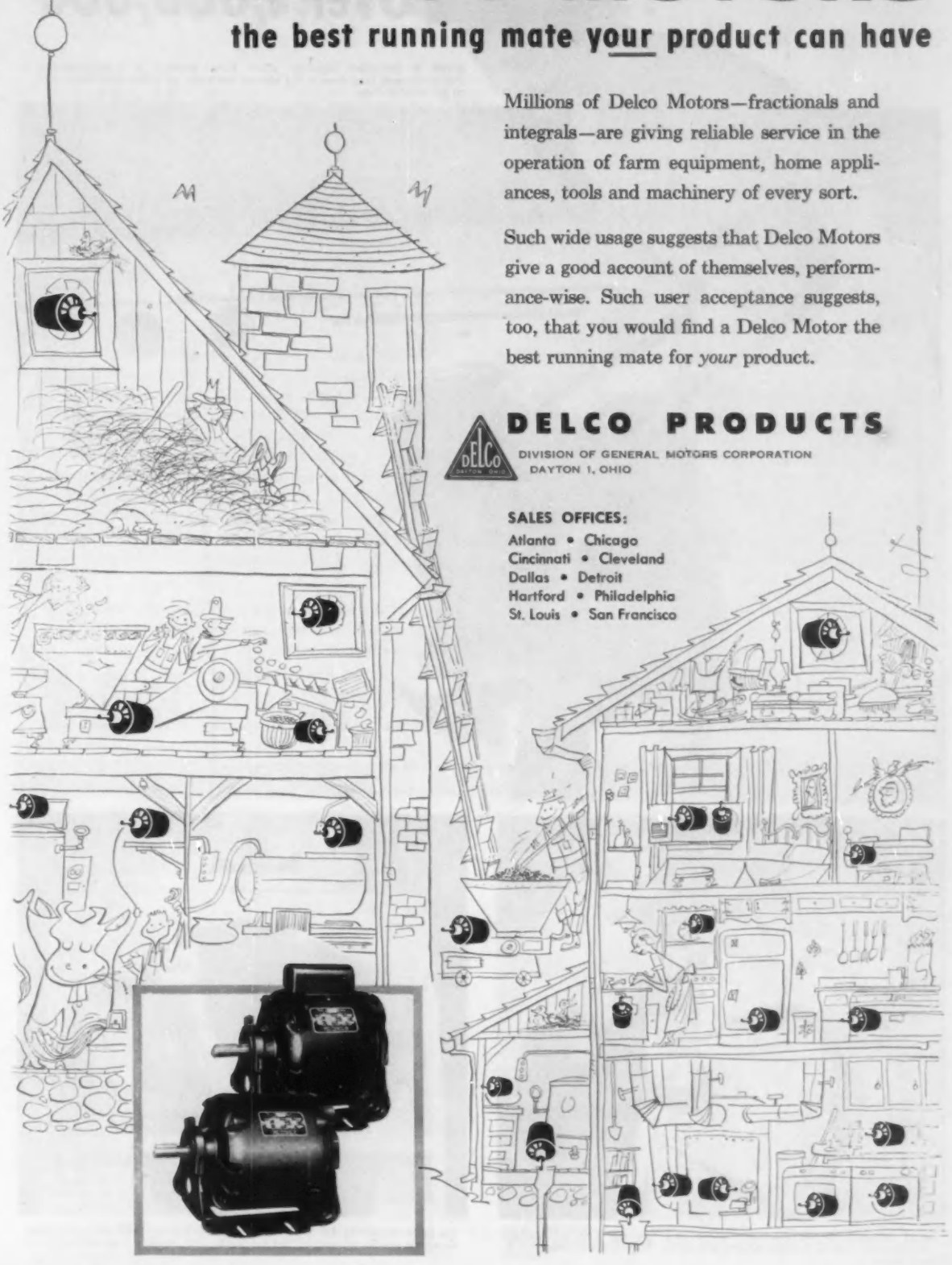
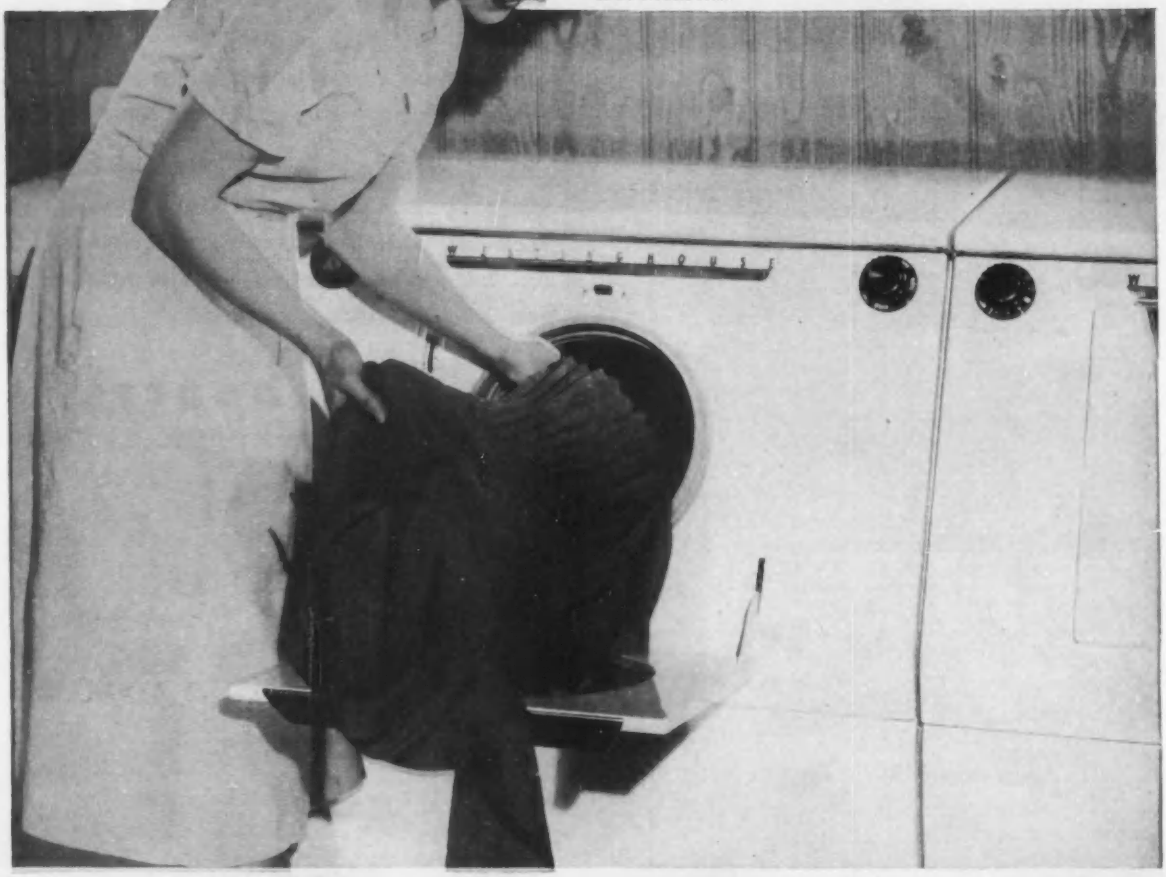
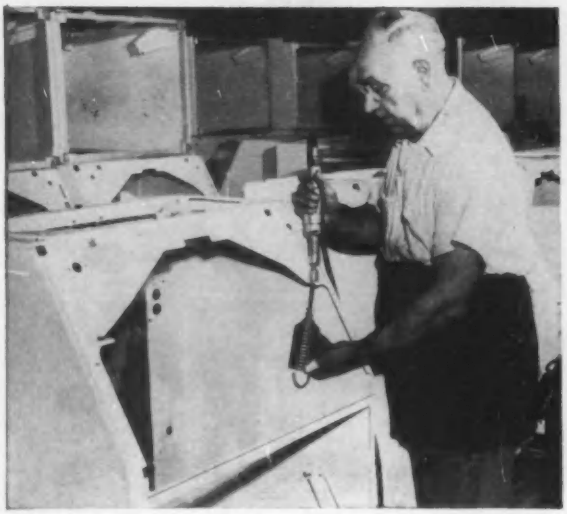


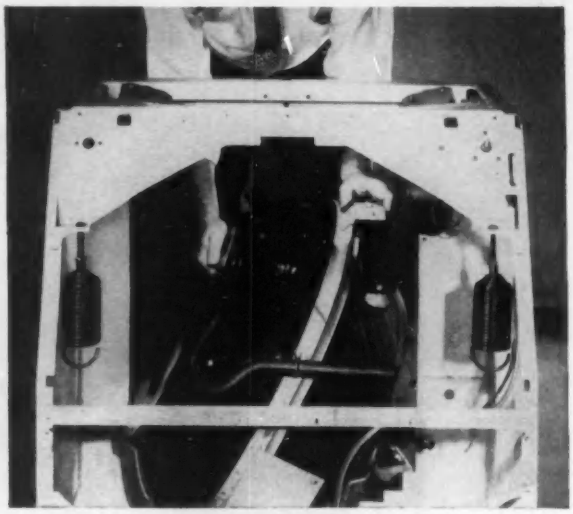
Over 1,000,000

OVER A MILLION families wash their clothes in Laundromats. Westinghouse also does a big export business, so these machines have to be trouble-free.





HERE, a man installs the main suspension springs. The springs are periodically tested to meet severe 450 c.p.m./⅝-inch amplitude, vibration tests.



AS UNIT IS INSTALLED in shell, man holds top damper spring. Notice damping blocks on end of flat spring to reduce excess movement.

Laundromats in use, but...

"We've never had a failure with American Quality Springs"

says WESTINGHOUSE ELECTRIC CORPORATION

THE Westinghouse Laundromat has been a household word ever since the first unit rolled off the production line in 1940. Since then, Westinghouse has produced over 1,125,000 Laundromats. Despite many important improvements, the superb spring suspension system has stood the test of time. It's the same today as it was in 1940, because it was designed so well in the first place.

Three different styles of American Quality Springs are used in the Laundromat. The *coil* springs support the entire weight of the machine within its shell. The *flat* steel springs contain friction dampers that limit excessive movement caused by an unbalanced load during the spin-dry cycle.

Failure of a coil spring could damage the entire machine. At the least, it would mean an expensive service call. But, because of the efficient design, and the completely reliable American Quality Springs, *no spring has ever failed in a Westinghouse Laundromat.*

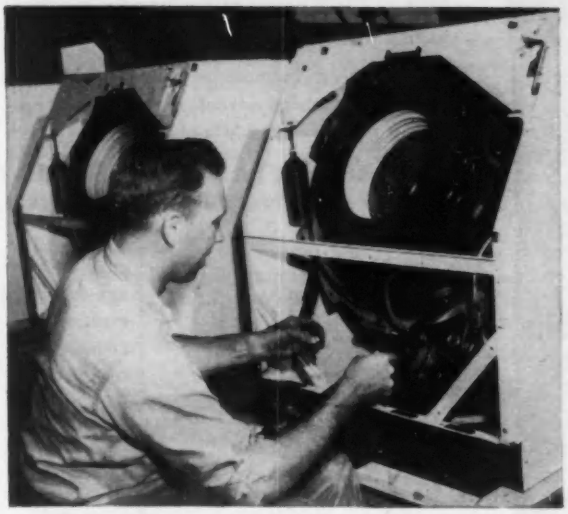
If service like this makes sense to you, get in touch with your nearest American Steel & Wire representative. We make all kinds of springs, any steel, any finish. And you'll get the same kind of quality that Westinghouse gets.

AMERICAN STEEL & WIRE DIVISION, UNITED STATES STEEL CORPORATION, GENERAL OFFICES: CLEVELAND, OHIO
COLUMBIA-GENEVA STEEL DIVISION, SAN FRANCISCO, PACIFIC COAST DISTRIBUTORS
TENNESSEE COAL & IRON DIVISION, FAIRFIELD, ALA., SOUTHERN DISTRIBUTORS • UNITED STATES STEEL EXPORT COMPANY, NEW YORK

USS

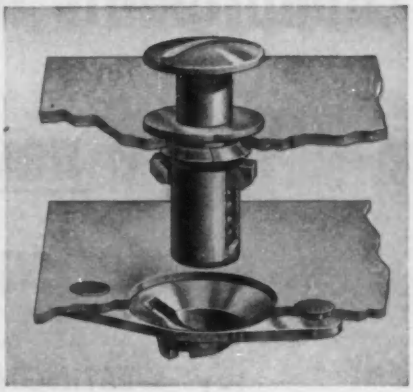
U·S·S American Quality Springs

UNITED STATES STEEL



BOTTOM DAMPER springs are installed. Because of the entire engineered suspension, Laundromat was one of the first washers that didn't have to be bolted to floor.

WESTINGHOUSE LAYS DOWN rigid specifications for their American Quality Springs, proving their motto, "Quality must be *built* into a product."



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Why do leading electronic manufacturers order and re-order Simmons' QUICK-LOCKS in quantity? For good dollar-wise reasons:

IN ASSEMBLY—

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- Flexible mounting takes care of curved sheets and misalignment.
- Various material thicknesses can be handled.

IN DESIGN—

- Initial loads taken by helical spring. Increased loads carried on solid supports.
- 90-deg. rotation locks and unlocks fastener.
- Stud is self-ejecting when unlocked.
- Stud is self-aligning. Makes mounting and demounting detachable panels simple.

QUICK-LOCK can help reduce your assembly costs and can add unusual advantages to your designs. Send for data and samples today.

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Fasteners that improve products and reduce assembly costs.

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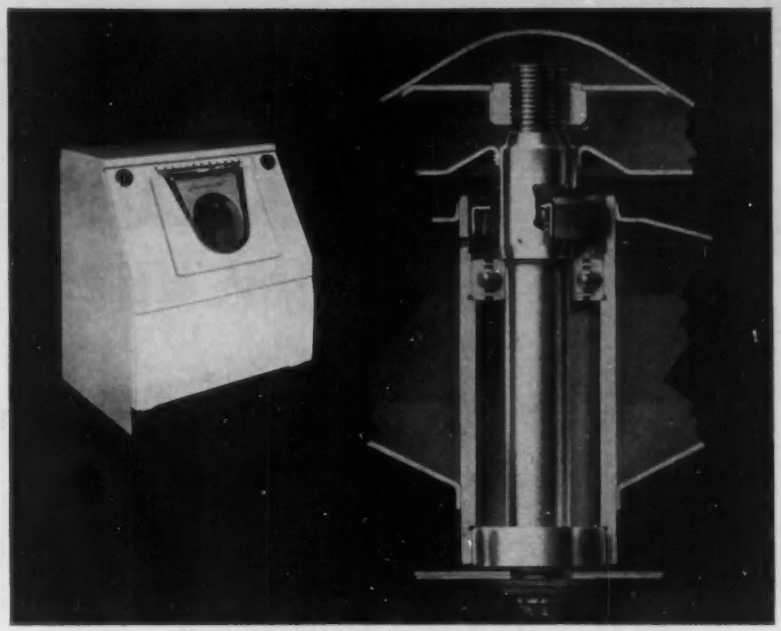

Figure 1. Spinner shaft assembly, Westinghouse Laundromat

Sealing two-speed vertical spinner shaft on Westinghouse Laundromat

In the Westinghouse Laundromat, sure and permanent sealing is essential on a 1.187" stainless steel spinner shaft that rotates at 500 R.P.M. during extraction and 50 R.P.M. during wash. Duty is intermittent, temperatures reach 180°F, sealing lips are in contact with detergent-laden or soapy water as well as calcium-base grease, and required life expectancy is 4,000 hours (20 years of normal service).

Westinghouse obtains the proper sealing by using a specially modified National 320,000 series Oil Seal with two sealing lips of National Syntech* synthetic rubber.

The main sealing lip, accurately spring-tensioned for maximum efficiency, serves to exclude water from the bearing assembly as well as retaining bearing lubricant. The auxiliary lip is springless, with an elongated "flex" section. Primarily a lint and dirt excluder, this lip runs without lubrication yet must not squeak when operated "dry." Both lips as well as the synthetic rubber O.D. covering are bonded to a steel inner case. The steel member provides rigidity which eliminates troublesome "fold-over" during installation and helps the seal remain permanently in position.

National Syntech Oil Seals, as well as National leather Oil Seals, are available in over 2,500 types and sizes. Where these seals do not precisely answer sealing requirements, modified or special seals can be designed. Your nearest National Applications Engineer has complete details; ask him for assistance next time you specify oil seals.

Figure 2. National 320,000 Modified Syntech Oil Seal

*T.M. Reg.

80,000 series external expansion leather seals

National 80,000 series spring-tensioned leather seals are designed for applications where the shaft remains stationary, the bore rotates, and the centrifugal force would impair operation of a shaft-type seal. Use of this external design in such cases often simplifies machinery design and facilitates assembly.

Modified standard-design seals with press-fit flange

Where the bore is not directly over the shaft section to be sealed, an off-set flange case may be specified. Illustrated is a conventional National 50,000 leather spring-tensioned seal with a flange press-fitting into the housing bore. 50,000 series leather seals are recommended for heavy-duty applications where seals may run semi-starved and dirt conditions are severe.

National O-Ring Catalog

National, a world leader in oil seals, offers a complete line of standard size commercial grade O-Rings. See the nearest National Applications Engineer or write direct to factory for catalog.

"Let Your Decision be Based on Precision"

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OIL & GREASE SEALS
O-RINGS SHIMS

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DETROIT, MICH. . . . . *726 Lothrop Avenue, TRinity 1-6363*
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MILWAUKEE, WIS. . . . *647 West Virginia Street, BRoadway 1-3234*
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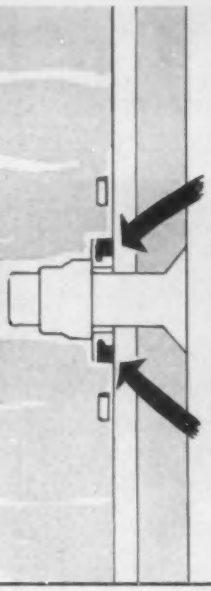
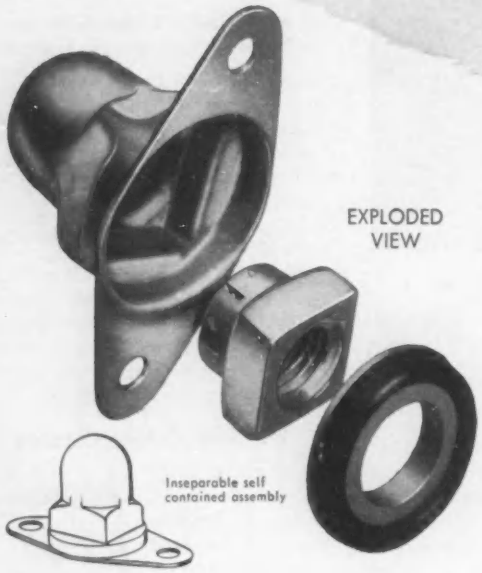
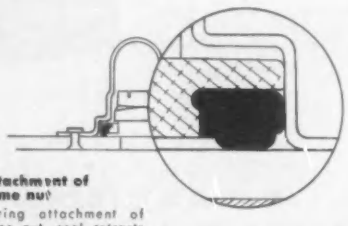
fluids can't penetrate this barrier



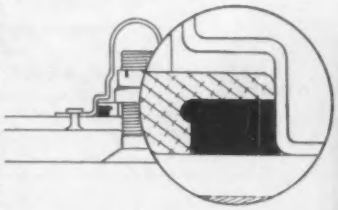
IN THIS SELF-SEALING DOME NUT

4630H SERIES





Attachment of dome nut
During attachment of dome nut, seal retracts into shell, but remains in contact with the structure. This eliminates pinching and subsequent cold flow of seal due to gaps which may exist between shell and the structure.



Installation of bolt
Installation forces the bearing surface of sealed washer to contact the structure, providing positive single point sealing.

REDUCE YOUR COSTS. Our ten years' experience with *specialized* fasteners can help you. Consultation, especially in the *design* stage, will result in a cheaper, more efficient fastener for your product. *Write today.*

Provides:

- ★ **High pressure sealing without sealing compounds**
- ★ **Inseparably self-contained assembly**
- ★ **Single point seal**
- ★ **Floating nut with stationary seal, unaffected by successive bolt installations**

Reduces Installation Time, Weight and Maintenance

Because seal is self contained, no sealing compounds are used resulting in reduced weight. Necessity for maintenance is almost eliminated.

SPECIFICATIONS

Self locking nut conforms to applicable requirements of AN-N-5. Available in 10-32 NF-3 and ¼-28 NF-3 thread sizes. Floats .025 in all directions.

Self contained seal conforms to applicable requirements for aircraft fuels type 1, 2 and 3 per specification MIL-R-6855. It is resistant to atmospheric elements, salt water, oil, gasoline and most organic solvents. Applicable temperature range: −80°F to +225°F constant or fluctuating operation. Applicable pressure range: ±50 psi constant or fluctuating operation.

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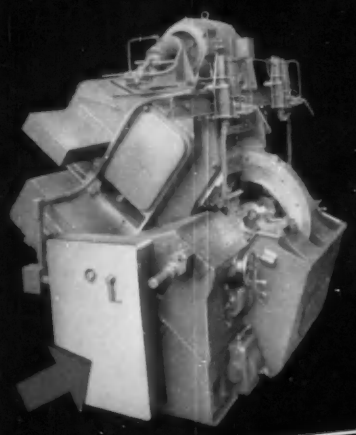
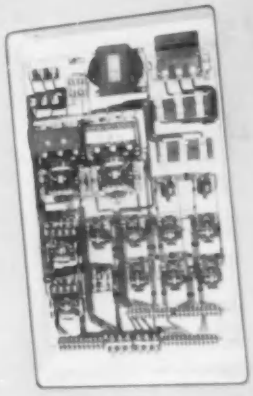


This LeBlond lathe has an Allen-Bradley control panel in cabinet at end of lathe. There are 20 components of which 14 are Allen-Bradley relays, contactors, and starters.

Allen-Bradley solenoid controls have ONLY ONE MOVING PART. No pins, pivots, or bearings to rust and stick. They are good for millions of trouble-free operations. That's why A-B controls are a sales asset to any machine tool.

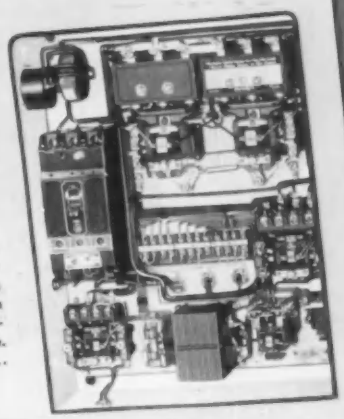


GORTON

ALLEN-BRADLEY CONTROL PANEL

This Gorton milling machine has an Allen-Bradley sequence control panel in the machine frame with 6 A-B solenoid-operated relays and starters, all equipped with silver alloy contacts that require no maintenance.

The ITE circuit breaker is interlocked with the door handle, which must be in OFF position to open cabinet. This is an important safety feature. Specify Allen-Bradley... and be safe.



TROUBLE-FREE CONTROL PANELS

FOR ALL TYPES OF MACHINE TOOLS

Today . . . more and more machines are being "factory-equipped" with Allen-Bradley control panels. Why? Because Allen-Bradley solenoid relays and contactors are so simple . . . ONLY ONE MOVING PART . . . they assure maintenance-free service for years.

ENGINEERED TO FIT YOUR NEEDS

Machine tool panels, designed and built by Allen-Bradley, provide dependable, automatic sequence control of machining operations . . . with split-second accuracy. Allen-Bradley control panels are all tailor-made to get the greatest output from machine tools of every type. Your near-by Allen-Bradley sales engineer will gladly discuss your control requirements.

Send for Bulletin
ALLEN-BRADLEY CO.
1316 S. Second St., Milwaukee 4, Wis.

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ALLEN-BRADLEY

QUALITY

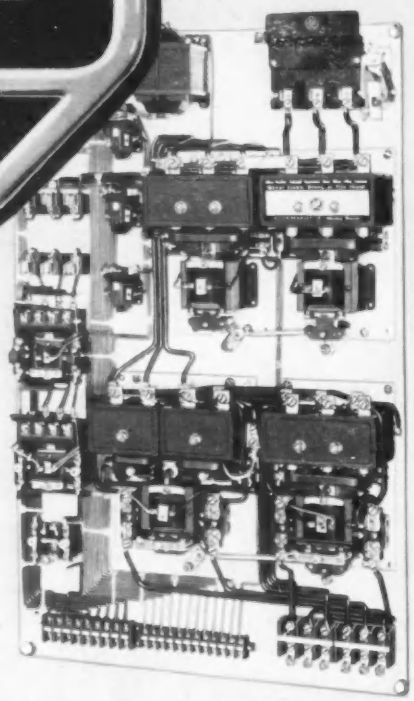
MOTOR CONTROL

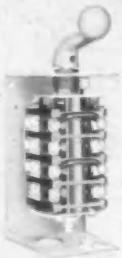
A-B Quality

QUALITY COMPONENTS

FOR MACHINE TOOL CONTROL PANELS

A-B Quality

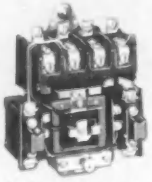




Bulletin 350
Drum Switch

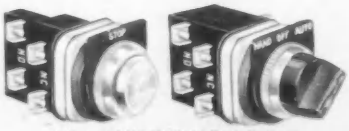
Bulletin 600
Small Motor
Starter

Bulletin 609
Manual Starter

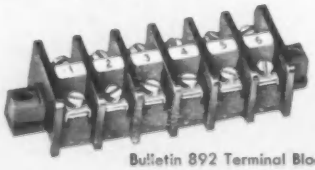


Bulletin 709 Automatic Motor Starter

Bulletin 702 Solenoid Contactor



Bulletin 800T Oiltight Push Buttons



Bulletin 892 Terminal Blocks

All components of Allen-Bradley control panels, like relays, contactors, starters, timers, fuse clips, or terminal strips, are long-established units in the A-B line. But while they have been field-tested in thousands of applications, they still are continuously tested during manufacture. That's how A-B control maintains its reputation for Quality. Specify Allen-Bradley.

Allen-Bradley Co., 1316 S. Second St.
Milwaukee 4, Wisconsin

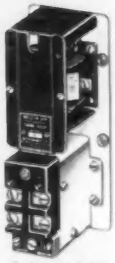
Bulletin 891 Fuse Clips

Bulletin 700
Universal
A-C Relays

Bulletin 200
D-C Relays

Bulletin 713
Starter and
Cir. Breaker

Bulletin 712
Starter and
Disc. Switch



Bulletin 849
Pneumatic
Timer

Bulletin 802T
Limit Switch

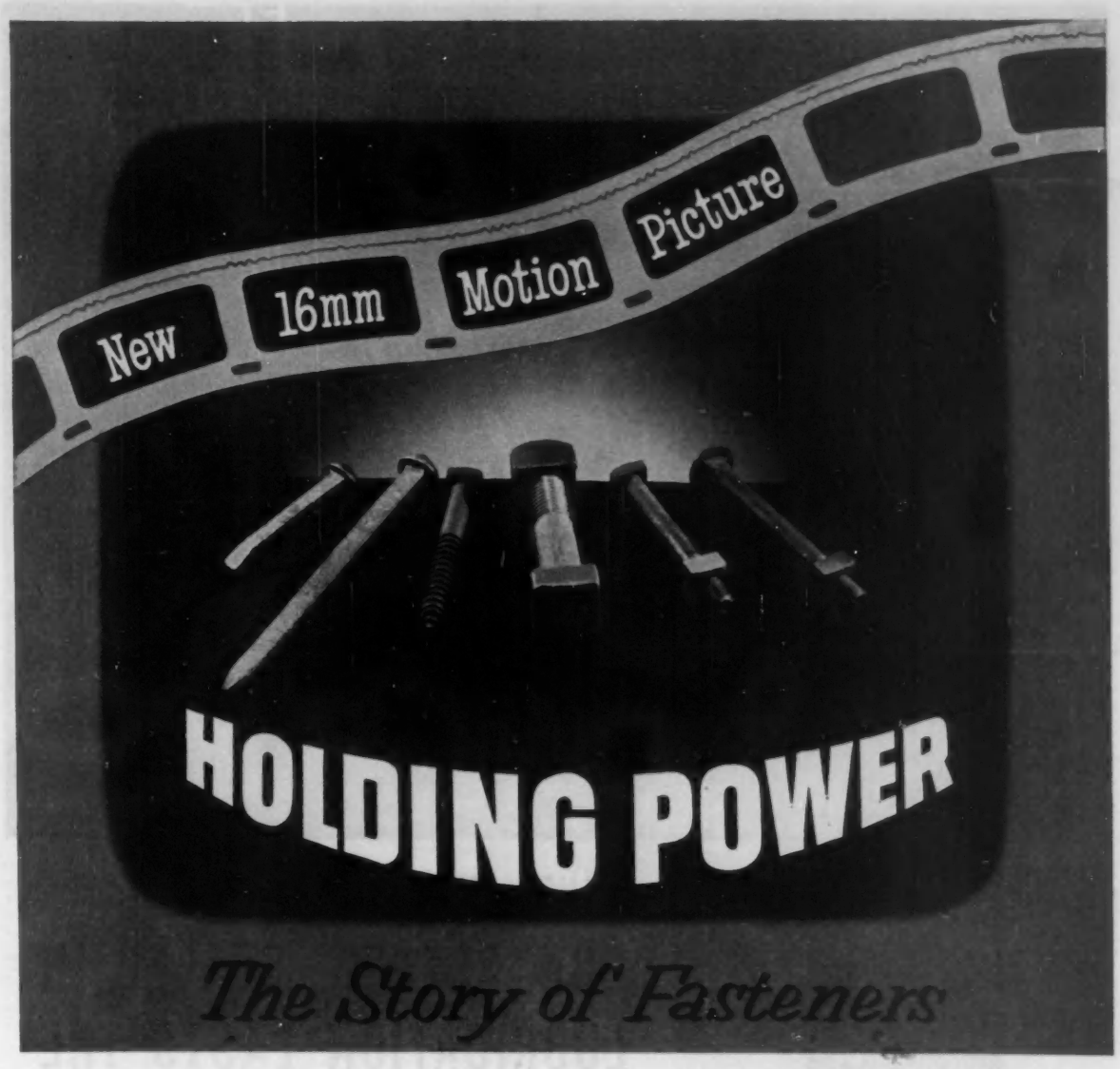
Bulletin 895
Auxiliary
Contacts

ALLEN-BRADLEY

QUALITY

TROUBLE-FREE MOTOR CONTROLS

3-54-R



This important new film dramatizes the story of fasteners. It delves into such common, everyday items as machine bolts, nuts, rivets, track bolts and spikes, and also describes roof bolts, high-strength bolts, oil-well sucker rods, and a wide range of special fasteners. The film takes you behind the scenes in our modern fastener plants. It shows how fasteners are made, and explains the vital part they are playing in industry.

"Holding Power" is in color, with sound. It is on 16mm film, and has a running time of approximately 25 minutes.

"Holding Power" is an ideal film for showing to distributors, consumers, and others closely associated with fasteners. It is also an interesting, highly educational picture for general audiences. There is no charge, except for the return postage. If you would like a print for showing, fill out the coupon, selecting a date well in advance, and mail it to Publications Department, Bethlehem Steel Company, Bethlehem, Pa.

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Gentlemen:

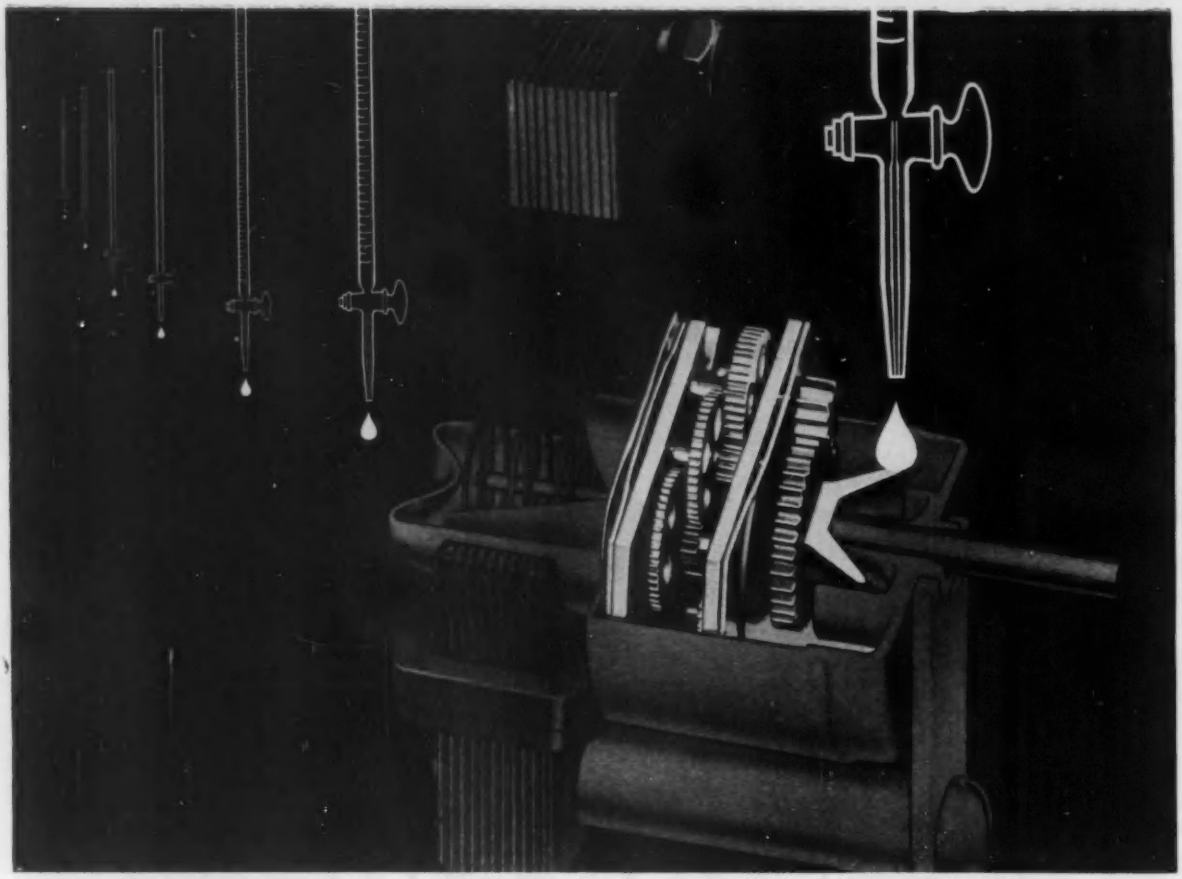
Please send me a print of your new film, "Holding Power." I will return it promptly, paying return postage.

Approximate date wanted_____

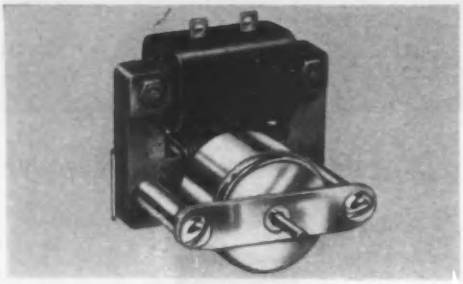
Send Print to This Address_____

Name of Company or Organization_____

MY-35 Signature_____



MORE evidence of the extra VALUE in TELECHRON timing motors...



Telechron motors play a major part in switching many of America's jobs to "automatic." They are unmatched in the field of electric timing with such features as lightweight rotors for instant starting... open-air design for cool running... and truly synchronous performance.

Big production by our automatic screw machines—typical of our large motor plant capacity—plus an experienced engineering staff, assure speed in deliveries.

CONTROLLED, SEALED-IN LUBRICATION LASTS THE LIFE OF THE MOTOR

Too much oil interferes with a timing motor's accuracy. Too little causes excessive wear. The key factor in the instant starting and long life of a Telechron timing motor is its unique controlled system of lubrication.

Each Telechron motor carries a lifetime reservoir of oil sealed in its rotor unit. Capillary action carries the oil to bearings, where its flow is controlled to all moving parts.

This exclusive lubrication system is one reason why—rating for rating—a Telechron timing motor will outlast and outperform any other synchronous timing motor made.

Telechron timing motors come in a wide range of speeds and torque ratings, for any standard AC power source. Write for full details about our Application Engineering Service. Telechron Department, General Electric Co., 13 Homer Ave., Ashland, Mass.

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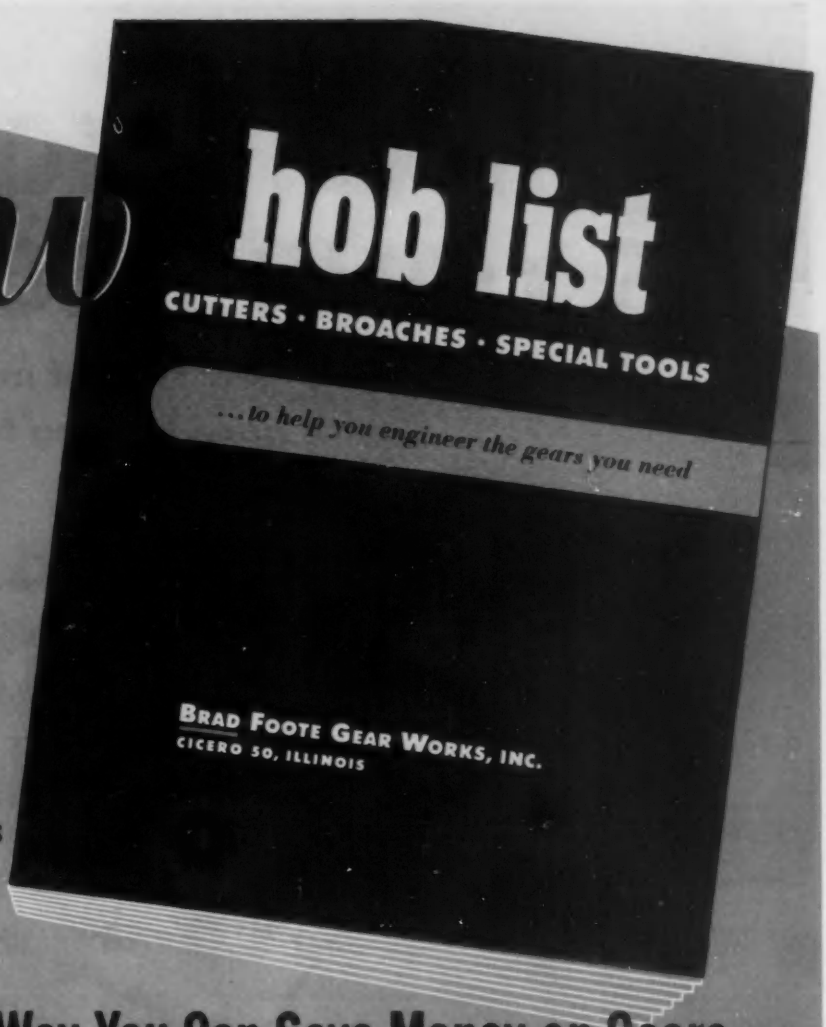
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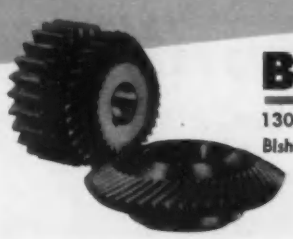

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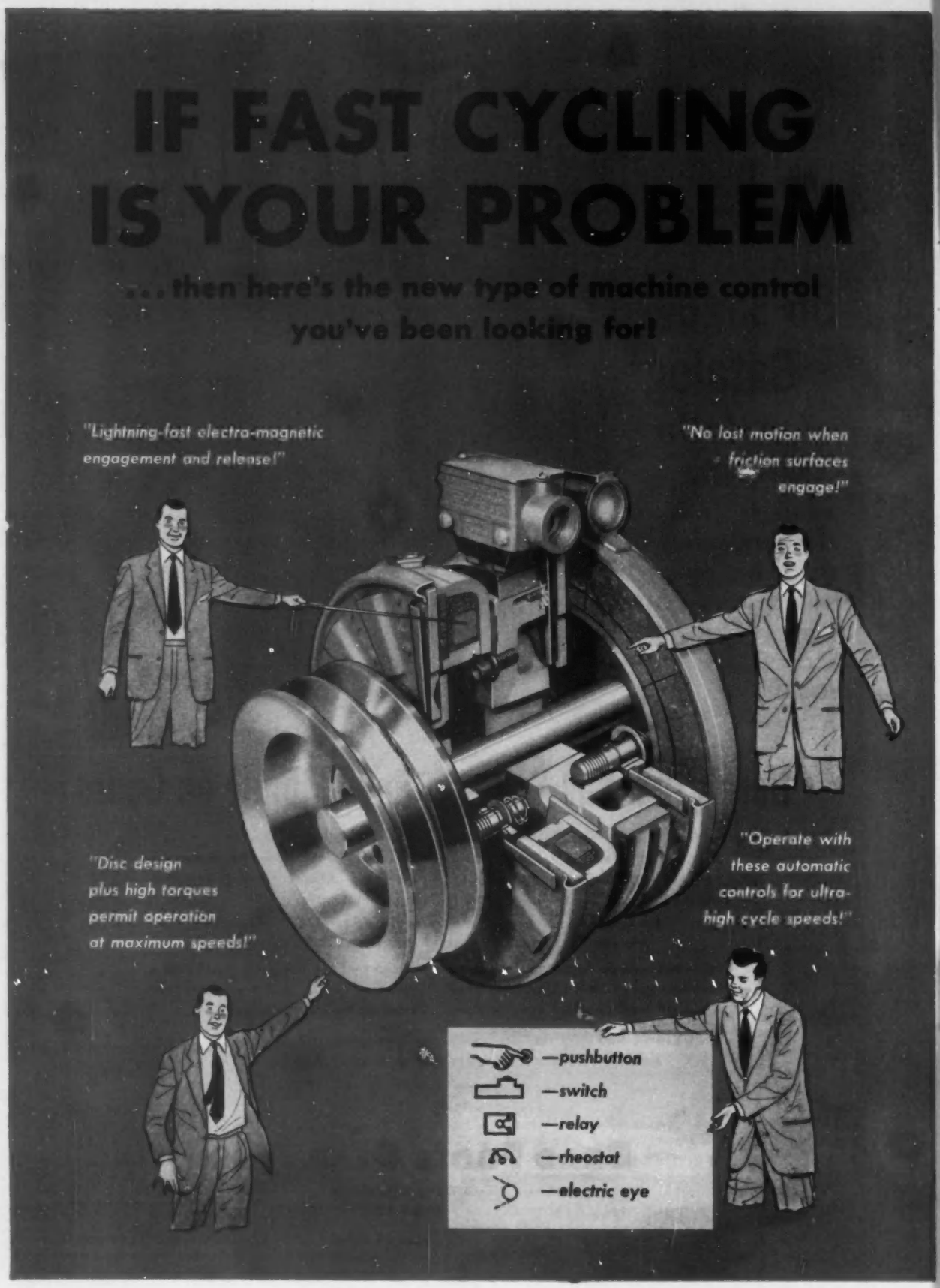
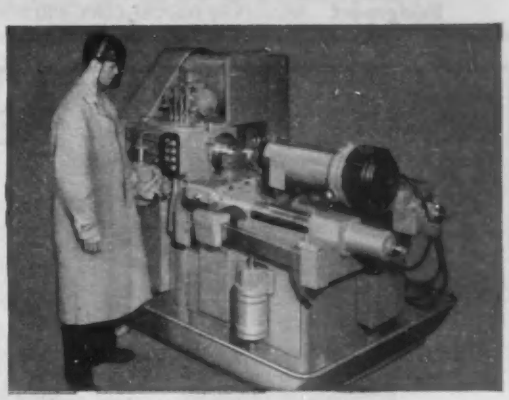
IF FAST CYCLING IS YOUR PROBLEM

. . . then here's the new type of machine control you've been looking for!

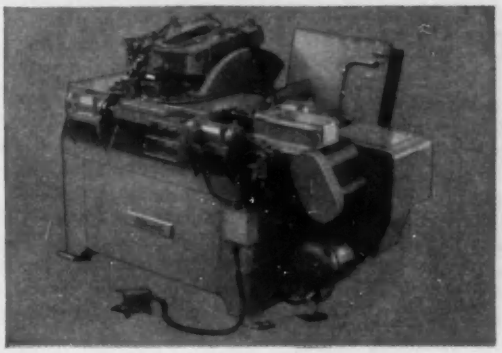

"Lightning-fast electro-magnetic engagement and release!"
"No lost motion when friction surfaces engage!"
"Disc design plus high torques permit operation at maximum speeds!"
"Operate with these automatic controls for ultra-high cycle speeds!"
—pushbutton
—switch
—relay
—rheostat
—electric eye

Warner Electric Brakes and Clutches offer proved advantages for fast cycling!

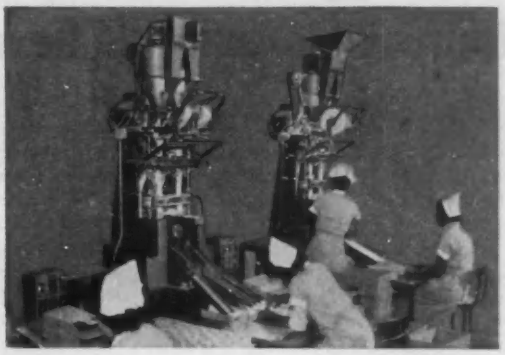
• Fast starting and stopping of high inertia loads with Warner Electric Brakes and Clutches (controlled automatically or by pushbutton) make today's fast-cycling machines even faster! If your machines are limited by cumbersome mechanical controls or slow-operating brakes and clutches, Warner offers an easy solution to both problems. *Electro-magnetic* principle permits use of electric controls for automatic operation. Manual operation is simplified by pushbutton control. Entire system is easily wired into standard machine circuits. Small switches, small contacts on relays, light-duty wiring, etc., may be used because power requirements are low. With virtually no *mechanical movement* or lost motion, and instantaneous *electrical* motive force, there's no limit to cycle speeds except the operation itself and physical demands on the operator. These typical examples show how improved control and faster cycling are possible on a variety of machines. Call your Warner representative or stocking distributor *today* for details and engineering help.



Gisholt Automatic Lathe has 7-second cycle, floor-to-floor. Only *7 seconds* is required to load, face, turn, cut off skirt and unload cast aluminum pistons on this Gisholt No. 12 Hydraulic Automatic Lathe. Fast pushbutton start of headstock spindle is controlled by Warner Electric Clutch-Coupling. Instantaneous stop provided by Warner Electric Brake is controlled *automatically* by limit switch. Operator loads and unloads faster because there is no coasting of spindle. Control is "fingertip" simple.



600 welds per hour . . . plus easier footswitch control! Quick as a *flash* . . . this Model F-3 Federal Welder clamps the workpiece, the Warner Electric Clutch engages, flash and upset take place, machine unclamps, clutch releases and Electric Brake engages—all at the rate of *600 cycles an hour*. Motor runs continuously, saving maintenance. Electric Clutch-Brake is easily controlled by a footswitch.



60-70 cycles a minute . . . expected life, ten years! New speed and accuracy of automatic packaging operations are possible with Warner Model 500 Electric Clutch-Brakes on auger feeds of Transwrap Model B Packaging Machines. On some operations, machines cycle *60 to 70 times a minute*, yet expected life of units is over 10 years. Clutches and brakes previously used required rebuilding after 30 days' use.

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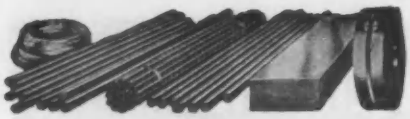
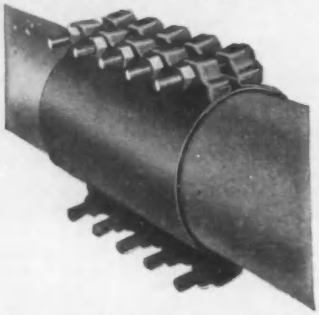


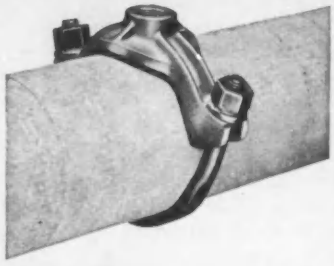
BRIDGEPORT BRASS COMPANY

COPPER ALLOY BULLETIN

Bridgeport Brass Co. MILLS IN BRIDGEPORT, CONN. AND INDIANAPOLIS, IND.—IN CANADA: NORANDA COPPER AND BRASS LIMITED, MONTREAL

Full Circle Clamp Coupling—copper strip for the band and Silicon Bronze screws and nut fasteners give strength and corrosion resistance. Courtesy Smith-Blair, Inc., South San Francisco, Calif.





Bronze Service Clamp for connecting risers. The cast bronze saddle and Neoprene gasket are assembled with a Silicon Bronze U-bolt and nuts for strength and long service life. Courtesy Smith-Blair, Inc.

Copper and Silicon Bronze Improve Repair and Service Clamps

Dependability, ease of installation, and excellent resistance to water and soil corrosion are characteristics of the metals used in the construction of clamps for sealing leaks, coupling pipes, and for service connections.

Illustrated is a Smith-Blair full-circle clamp coupling made from two half-circle bands of cold rolled, tough pitch copper, lined with molded rubber gaskets bonded to the copper. When firmly clamped together by means of high-strength silicon bronze bolts and nuts, this clamp enables one man to permanently repair a broken or cracked pipe in a few minutes with a minimum amount of excavating.

The fact that copper is flexible, as well as enduring, was an important factor in its selection. The heavy copper sleeve gives uniform distribution of the clamping pressure without crushing. This is very desirable for coupling cast iron, and especially for cement-asbestos pipe.

Silicon Bronze for High-Strength Service Clamps

The bronze service clamps are constructed with U-bolts made of silicon bronze wire or rod. Bolts made from Bridgeport's Silicon Bronze (609) (approx. 98% copper, 2% silicon) have a tensile strength of approximately 90,000 psi. Silicon bronze is so close to copper in the electromotive series that there is no danger of galvanic corrosion between the copper sleeve and the silicon bronze bolts. It also has the corrosion resistance of copper as well as the toughness of mild steel.

Silicon bronze is an engineering alloy that is fast replacing perishable metals for all types of fasteners. It is widely used in the electrical and marine fields for the construction of wire and cable connectors, pole-line hardware, marine hardware, sewage and waterworks, industrial equipment, valves, controls and all varieties of bolts, nuts, nails, and screw products used for outdoor construction.

Call on Bridgeport for Copper or Copper-Base Alloys

Bridgeport's Laboratory will be glad to cooperate with you in providing the right metal for your specific purpose. To obtain help on your metal problems or requirements, please contact your nearest Bridgeport office. Write for your copy of Bridgeport's "Technical Handbook" on company letterhead.

Duronze III Stops Accidents

The gate on the safety hook illustrated depends upon a lock pin made from Duronze III for controlling its opening and closing. The gate cannot be opened until the pin is pressed in.

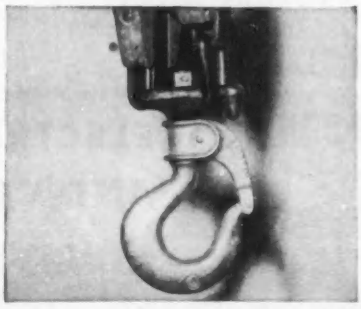
Since the pin must function under all conditions, even when not lubricated, Duronze III (707) rod, an alloy of high strength and with excellent corrosion and wear resistance, was selected.

The sleeve for the pin is made from Ledrite 6 Brass rod because there is a low coefficient of friction between these two metals. The gate itself is cast Red Brass, and the washer on top of the hook is bearing bronze. The wide use of copper-base alloys reduces corrosion and prevents the freezing of moving parts when exposed to water and moisture even for long periods.

Duronze III (707), with 91% copper, 7% aluminum and 2% silicon, is supplied in rod form only, and has a tensile strength in the annealed state of between 85,000 and 90,000 psi. It answers the product designers' demand for high functional strength and, at the same time, eases the problems of the tool engineer and production department by its good machinability, which is 60% of free machining brass.

For additional information on Duronze III alloy, write for the Duronze Manual.

The safety pin made from Duronze III (Silicon Aluminum Bronze) controls the cast bronze gate which prevents the load from slipping off the hook. Courtesy C. E. Bullard Co., San Francisco.



(1307)

New freedom of design with U. S. PowerGrip "TIMING" BELTS

SMALLER PULLEYS • NO MORE OIL-RETAINING HOUSINGS
LONGER SERVICE LIFE • GREATER MACHINE EFFICIENCY

The designer shakes himself free of many obstacles when he can work with U. S. PowerGrip TIMING® Belts. These split-second power transmitters are used on hundreds of such machines as lathes, drill presses, electric typewriters, floor washing machines, saws. *The list grows day by day.* Check points below!

FAST DELIVERY
COMPLETE ENGINEERING SERVICE
FULL STOCKS

Absolutely no slippage or creep in the belt • No need for lubricants, oil-retaining housings – because there is no metal-to-metal contact • Very small pulleys can be used, thus permitting very short centers and high ratios. No take-up needed because belt is practically stretchless • H.P. range is 1/100 to 300 or more. *Stock* drives go up to 50 H.P., but wider belts and pulleys can be made to order in standard lengths and diameters • U. S. PowerGrip TIMING Belt permits lighter bearings, lighter metals–cuts costs • Immediate delivery from coast-to-coast offices.

Send for descriptive literature. Get in touch with any of the 25 United States Rubber Company District Sales Offices, or write to address below.

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ELECTRIC MOTORS
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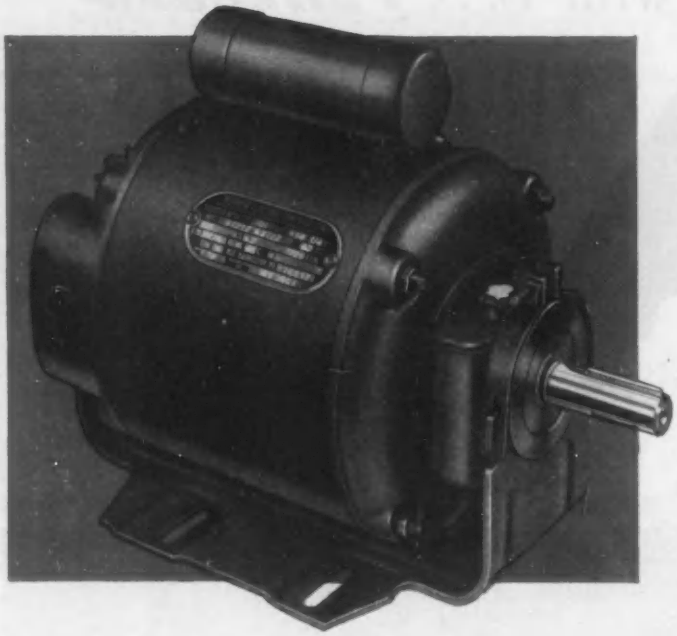
for a Capacitor-Start



Type RK fits your needs for applications requiring high starting torque

Wagner capacitor-start induction motors are a sound choice for applications where starting loads are fairly heavy, but which can be brought up to operating speed quickly. They have become increasingly popular for installation on equipment such as air conditioners, refrigerators, freezers, water pumps, motor-driven tools, and on similar fractional or integral horsepower applications.

These motors offer low maintenance cost—only a minimum of servicing is required—and they give many years of reliable service with unusual freedom from vibration and noise.

These motors are available in frames 225 and smaller, in open or totally-enclosed types—sleeve or ball bearing, with rigid or resilient bases or machined endplates for flange mounting. Frames are formed of heavy rolled steel. The rotor squirrel-cage is of aluminum, cast under pressure. Type RK capacitor-start induction motors feature steel-backed babbitt lined bearings, roomy oil wells packed with long strand wool yarn, and dependable quick make-and-break switches which have proved their ability in service.

Wagner Electric Corporation
EST. 1891

WAGNER ELECTRIC CORPORATION
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ELECTRIC MOTORS • TRANSFORMERS • INDUSTRIAL BRAKES
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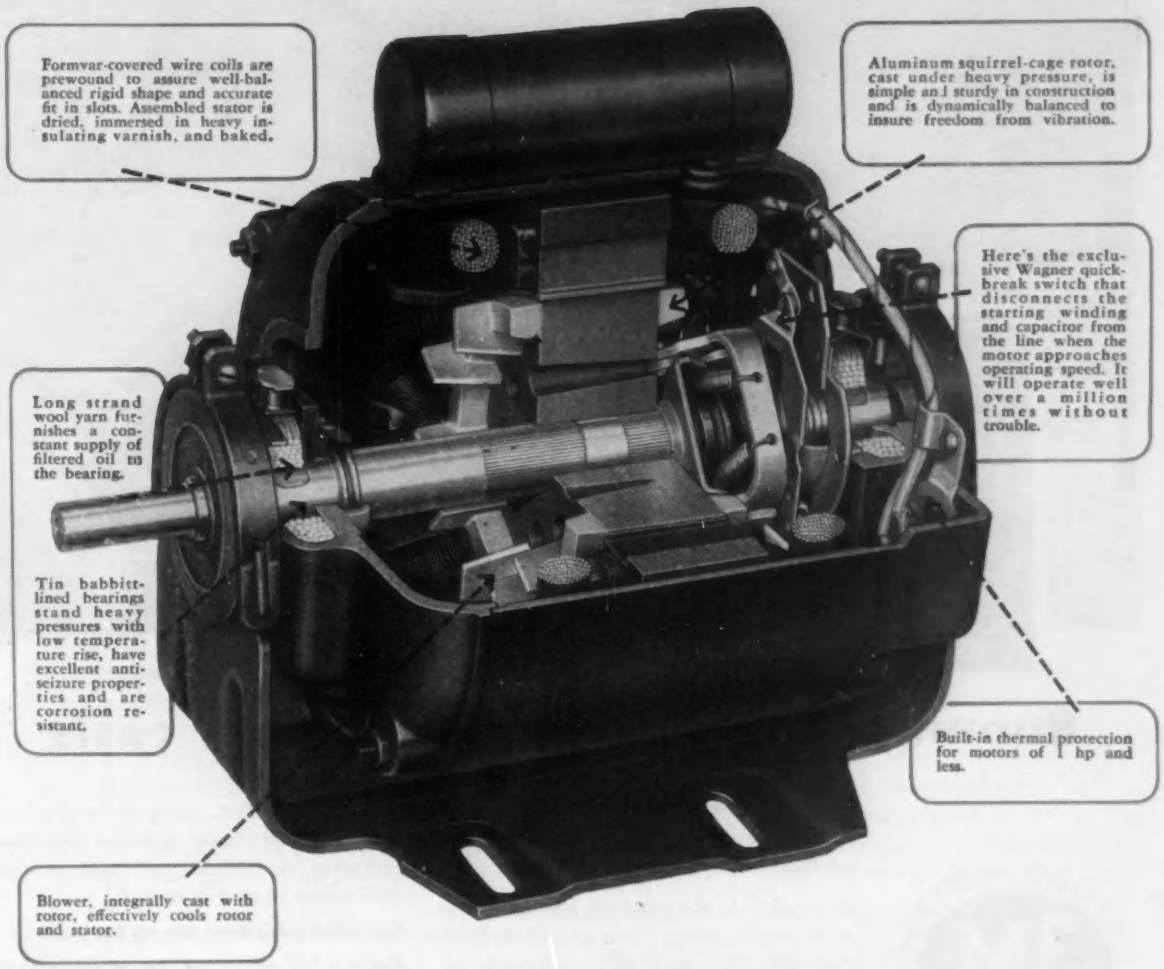
choose the Wagner Type RK


Formvar-covered wire coils are prewound to assure well-balanced rigid shape and accurate fit in slots. Assembled stator is dried, immersed in heavy insulating varnish, and baked.
Aluminum squirrel-cage rotor, cast under heavy pressure, is simple and sturdy in construction and is dynamically balanced to insure freedom from vibration.
Here's the exclusive Wagner quick-break switch that disconnects the starting winding and capacitor from the line when the motor approaches operating speed. It will operate well over a million times without trouble.
Long strand wool yarn furnishes a constant supply of filtered oil to the bearing.
Tin babbitt-lined bearings stand heavy pressures with low temperature rise, have excellent anti-seizure properties and are corrosion resistant.
Built-in thermal protection for motors of 1 hp and less.
Blower, integrally cast with rotor, effectively cools rotor and stator.

When you standardize on Wagner Motors—you get the advantages of a liberal warranty... of nationwide service facilities, with on-the-spot service, replacement motors and parts available from 25 Wagner-owned Service Branches and more than 750 Authorized Service Stations. You can choose from a wide variety of types and sizes—singlephase or polyphase—(from 1/125 to 400 hp). Bulletin MU-185 gives complete information—write for your copy.

See what adhesives are doing today!

Running rings around assembly costs

Here's another example where comparison proves the advantage of adhesives over mechanical means for fastening.

At Crosley, to complete the assembly of a compressor housing, three operations were required: (1) a weld, (2) positioning of steel lid, (3) shooting the fastening screw. When Crosley switched to the use of a 3M adhesive, EC-847, for this operation, the number of parts needed was reduced, production time was cut down, and savings in assembly costs were realized.

As a matter of fact, today at Crosley, one man (pictured above) performs the entire operation, maintains production of over 1000 pieces in an 8-hour shift.

See what adhesives can do for you . . .

Perhaps 3M adhesives can better perform your fastening operations, too. To check, just call in your 3M salesman. For a free booklet giving examples of how 3M adhesives can help, write today to Dept. 43, 3M, 417 Piquette Ave., Detroit 2, Mich.

see our catalog in PRODUCT DESIGN FILE or write for copy

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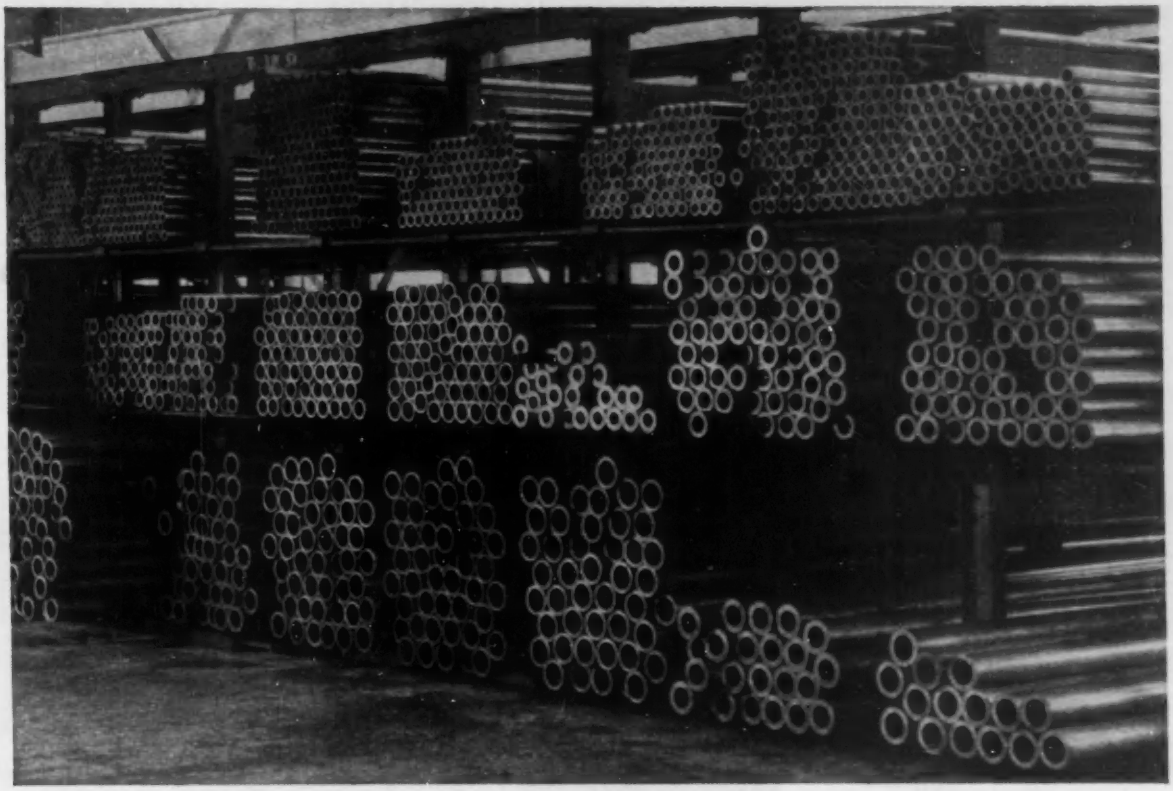

What size 52100 steel tubing do you need? We'll ship tomorrow!

WE carry 101 different sizes of Timken® 52100 steel tubing in warehouse stock—from 1" O.D. to 10½". If you order today, we'll ship tomorrow!

52100 is a high-carbon chromium steel that will do most of your hollow parts jobs. In moderate sections it will through-harden and it has been used in place of more expensive steels. You can heat treat it to file hardness and then temper back to any desired point.

Timken 52100 steel is ideal for hollow-parts jobs like these: aircraft parts, ball bearing races, pump parts and plungers, collets, bushings, spindles, grinding machine parts and precision instrument parts.

The Timken Company is America's pioneer producer of 52100 tubing. We have a background of experience in making it that can't be equalled. We've developed rigid quality control procedures that check every step of the operation. Result: uniform high quality from tube to tube, heat to heat.

Write, wire or phone us now for immediate delivery of your less-than-mill-quantity orders of 52100. The Timken Roller Bearing Company, Steel and Tube Division, Canton 6, Ohio. Cable address: "TIMROSCO".

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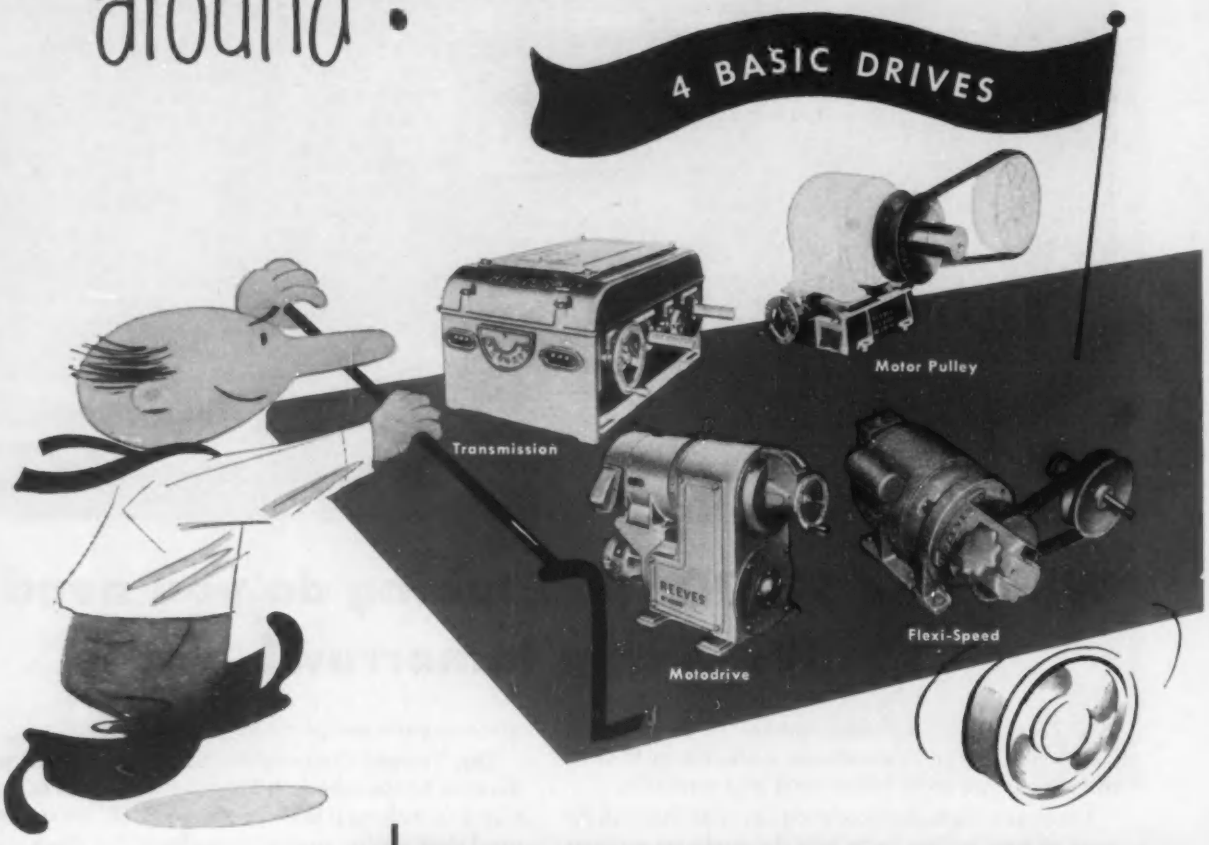

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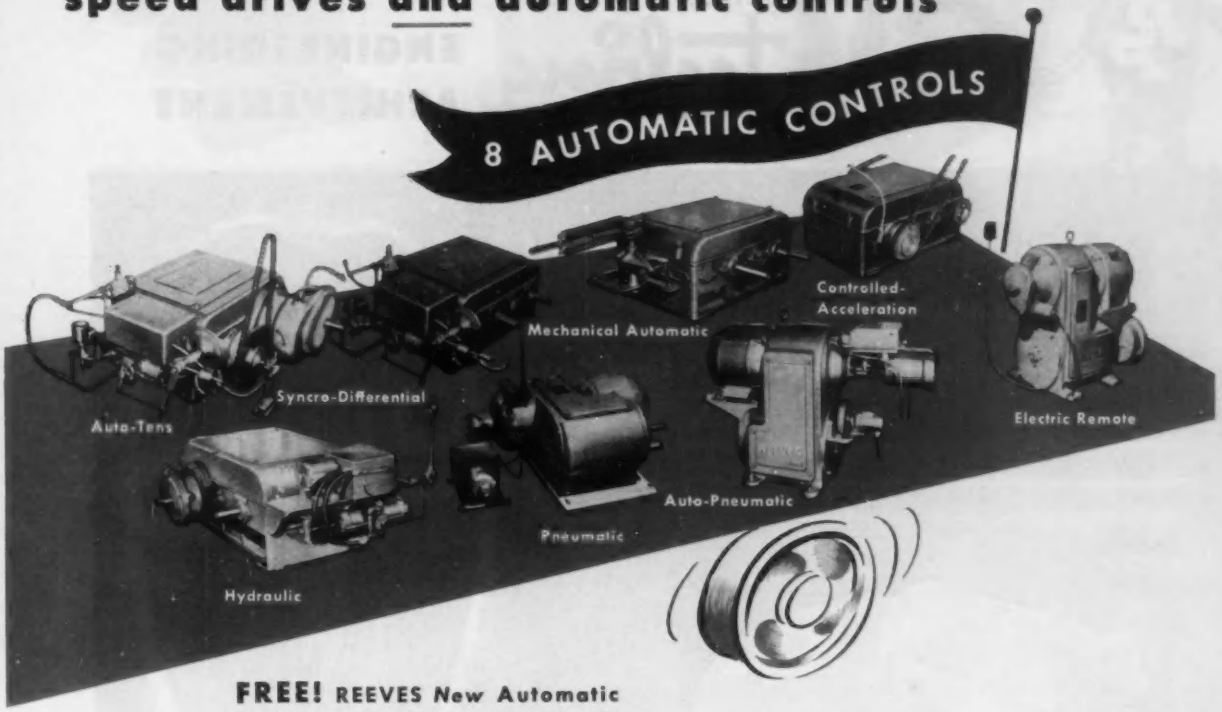
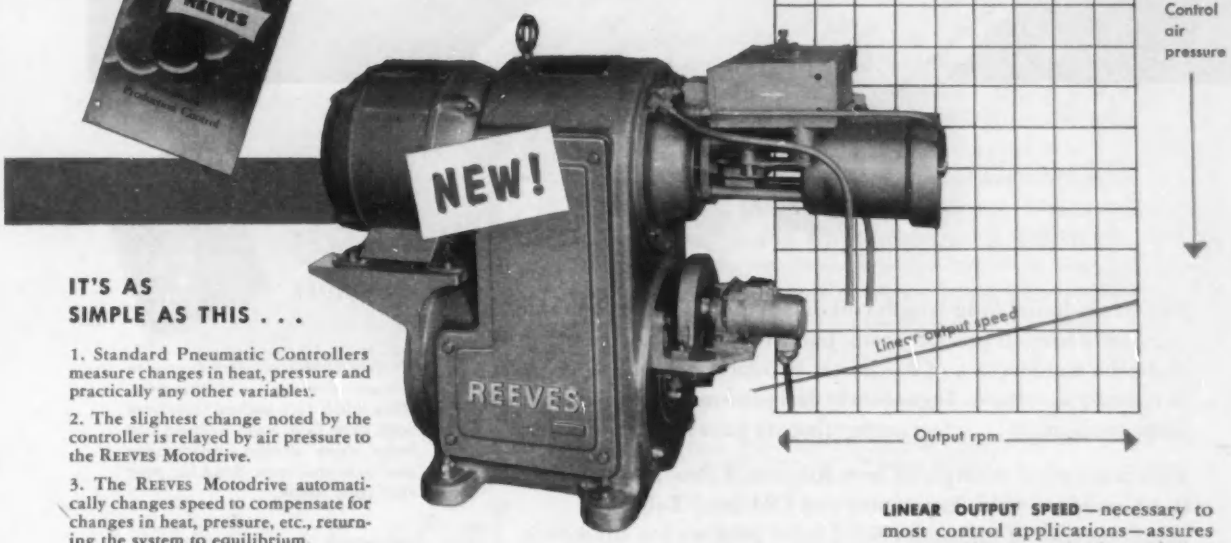
Amazing *new* Flexi-Speed is but one outstanding example of the complete line of REEVES Variable Speed Drives. Now available with output speeds from 300 rpm to 4800 rpm—speed ratios as great as 8:1. Combines efficiency, versatility and *low price.*

offers the only complete line of variable speed drives and automatic controls



FREE! REEVES *New* Automatic Production Control Booklet — Specify K4-G537



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LINEAR OUTPUT SPEED—necessary to most control applications—assures exactness for proportioning and gives precise speed control *throughout the entire range* of the Motodrive.

REEVES AUTO-PNEUMATIC CONTROL

for regulating flow, pressure, heat, etc.

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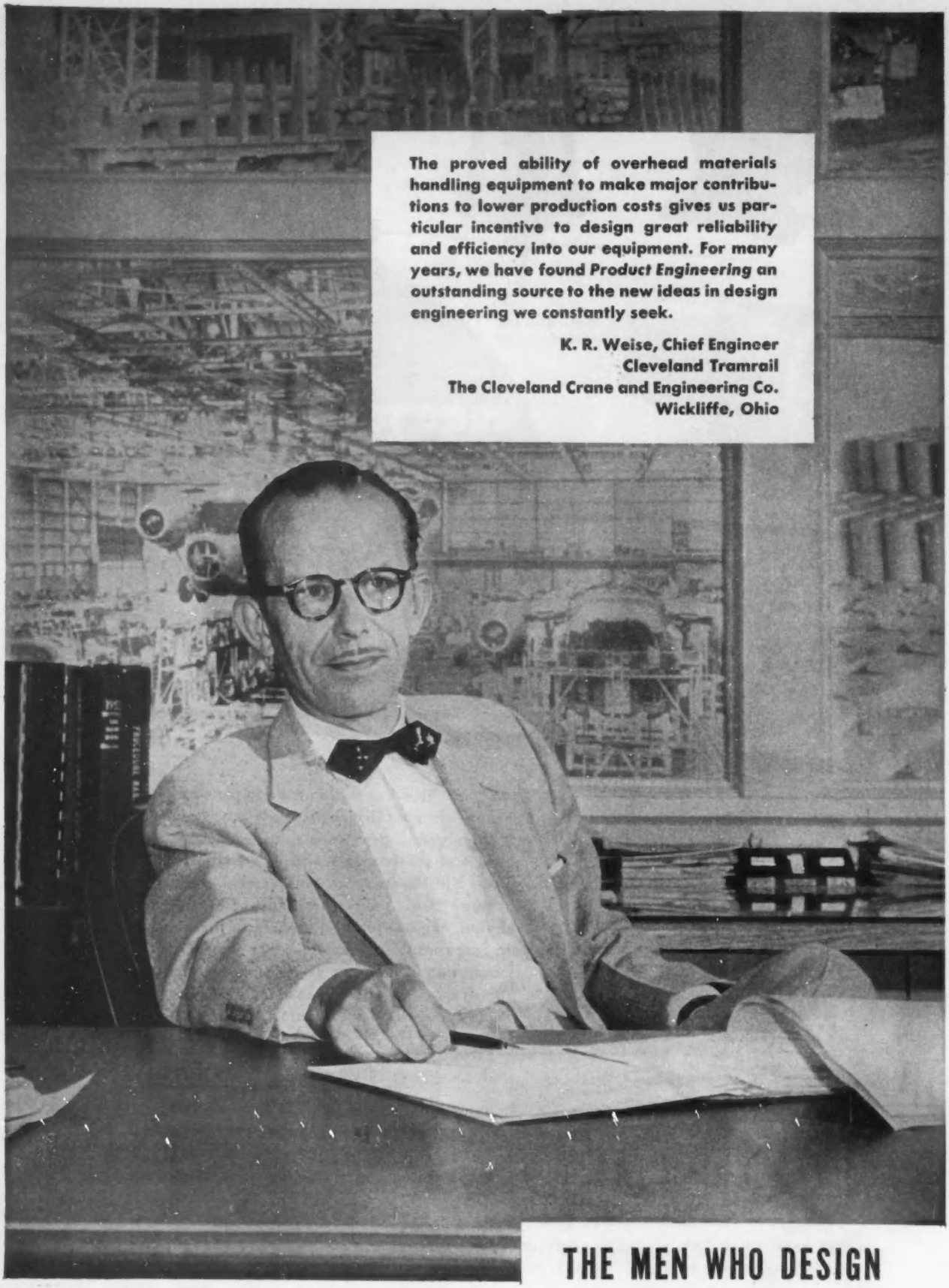
City.....*Zone*.....*State*.....



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K. R. Weise, Chief Engineer
Cleveland Tramrail
The Cleveland Crane and Engineering Co.
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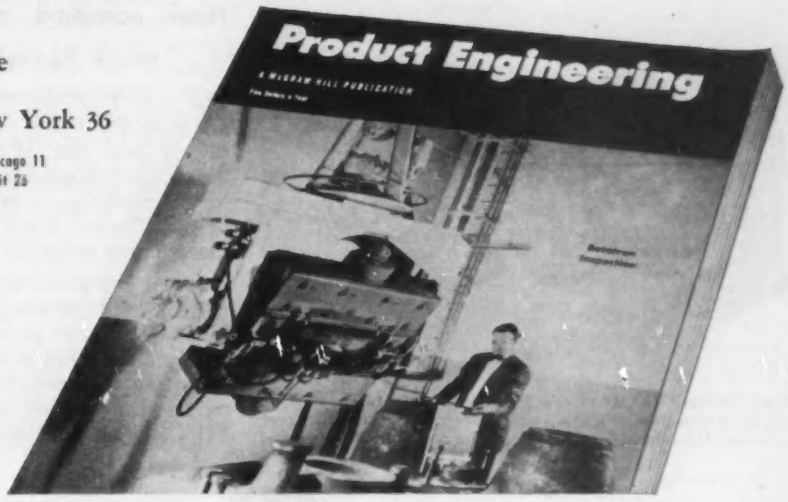
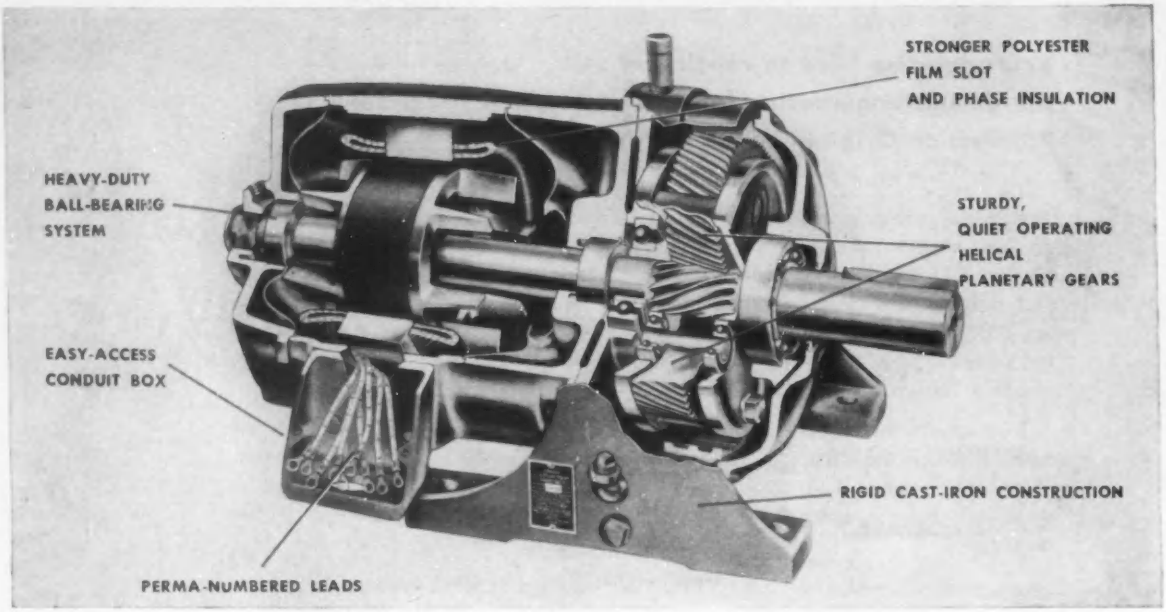


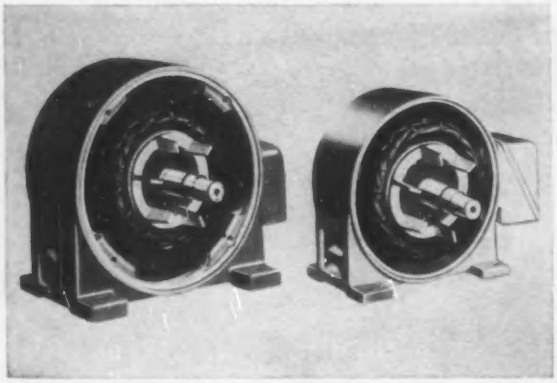
AMERICA'S NEW PRODUCTS READ PRODUCT ENGINEERING

Designer's



CUTAWAY VIEW OF SINGLE-REDUCTION TRI/CLAD '55' GEAR-MOTOR

Now G-E gear-motors are built with the all-new TRI 55 CLAD motor



MORE COMPACT FRAME of new Tri/Clad '55' motor (shown at right) makes new G-E gear-motor lighter, smaller, with full power rating of previous models. More floor space is thus freed for aisle room or machinery.

New compact motor design gives you more horsepower in less space

The new Tri/Clad '55'—the foremost advance in the art of motor design—is now an integral part of a completely new line of G-E gear-motors. A neat, well balanced arrangement of motor and gears gives you the low-speed drive you need for your most modern machine design. Unused space has been reduced to make this motor easier to handle and easier to install.

When you select G-E gear-motors you eliminate the necessity of ordering, assembling, and maintaining separate parts to get the drive you want. The new line covers a wide range of power ratings, voltages, speeds mounting arrangements and enclosures. Lighter weight reduces shipping and handling costs. For the entire G-E Tri/Clad '55' gear-motor story, see Bulletin GEA-6027.

GENERAL ELECTRIC

Digest

MOTOR & CONTROL HIGHLIGHTS

EASY-TO-MOUNT FIELD RHEOSTATS PERMIT ACCURATE SPEED ADJUSTMENT

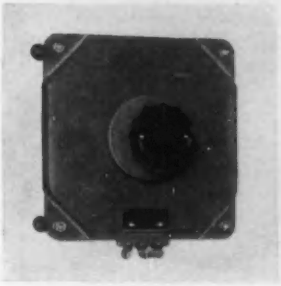
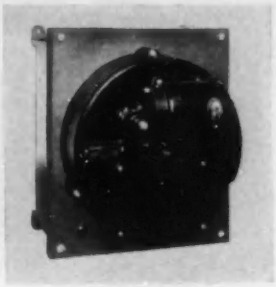


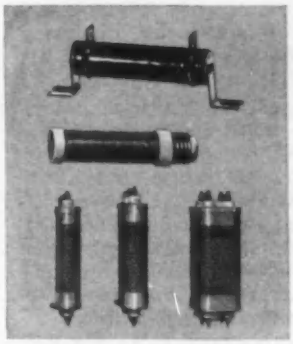
Plate-type



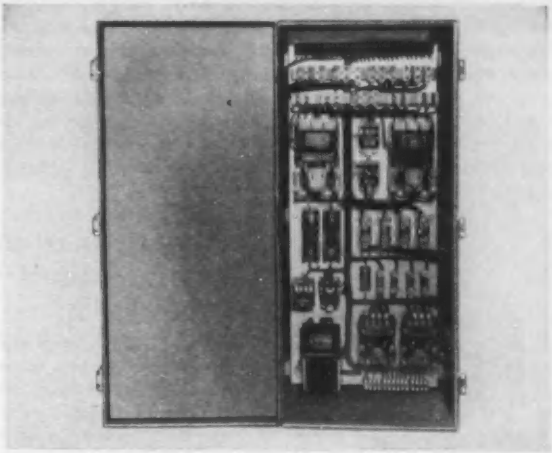
Tube-type

For speed control of d-c motors, or voltage control of generators and exciters, you'll want a General Electric field rheostat. Both plate-type and tube-type can be manually, chain or motor-operated to suit your particular machine-tool application. Accuracy of speed adjustment is provided, in most cases, by over fifty divisions of resistance. To give added flexibility adjustable stops may be located at any position between ends of travel. Special alloy resistance material assures long life. Four-point mounting simplifies installation and eliminates the need for additional feet or brackets. Three plate-type sizes are available: 12-inch with 70 resistance steps, 9-inch with 52 steps, and 6-inch with 27 steps. For further information send for Bulletin GEA-3222.

ENAMELED RESISTORS WITHSTAND EXTREME TEMPERATURE CHANGES



Here's a big selection of General Electric enameled resistors designed to withstand sudden and extreme temperature changes without damage. Simplest control product manufactured, each unit has a standard ±5% resistance tolerance, which makes it extremely adaptable for innumerable design applications. A vitreous enamel coating, applied after winding, gives mechanically airtight and moisture-proof construction, provides long life. The low temperature coefficient of the nichrome wire permits resistance to remain nearly constant as temperature increases. Circular-band terminals or wire leads are furnished as desired. For complete information, request Bulletin GEC-817.



Save 4 ways with custom-built G-E industry control panels

General Electric custom-built industry control panels can save you time, effort and cost. That's because G.E. designs and tests these panels for your specific applications. Your results are as follows: (1) **You reduce** the load on your own design and drafting staff, releasing them for other projects. (2) **You save** on inventory and storage costs of components. (3) **You eliminate** assembly and wiring and cut installation costs. (4) **You avoid** the need to set up a separate maintenance organization to service the control panel. G.E's extensive service facilities includes 31 Apparatus Service Shops throughout the country. For further information, see your G-E Apparatus Sales representative.

General Electric Company, Apparatus Sales Div.,
Sec. A668-112
Schenectady 5, New York

Please send me the following Bulletins:
√ for reference purposes × for immediate projects
☐ **GEA-3222 Field Rheostats**
☐ **GEA-6027 Tri/Clad '55' Gear-motors**
☐ **GEC-817 Enameled Resistors**

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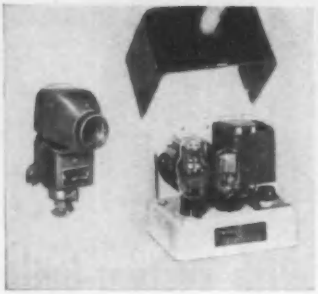
TURN PAGE FOR MORE G-E PRODUCT HIGHLIGHTS

G-E ELECTRONIC RELAYS HELP SOLVE MANY DESIGN PROBLEMS

A complete line of General Electric relays, ranging from low to highly sensitive units, are now available. These versatile electronic devices give you fast operation, precise control, automatic operation, and flexibility in machine design. Each unit and standard accessory is simple to install, adjust and maintain. Various enclosures for specific applications are available in the line. Here are two types of standard G-E relays that can help you solve a great many complex design problems quickly and easily.



Photoelectric relays sort, count, signal—automatically

Now G.E.'s simple photoelectric relays can cover up to 600 operations, and in combination with standard accessories it is possible to meet an even wider range of applications. G-E photoelectric relays provide an inexpensive way to accurately, automatically control many operations for large industrial and small commercial installations.

Changes in light-level settings are easily made by means of an adjustment knob. It only takes a few seconds for light source or phototube holder to be focused and aimed.

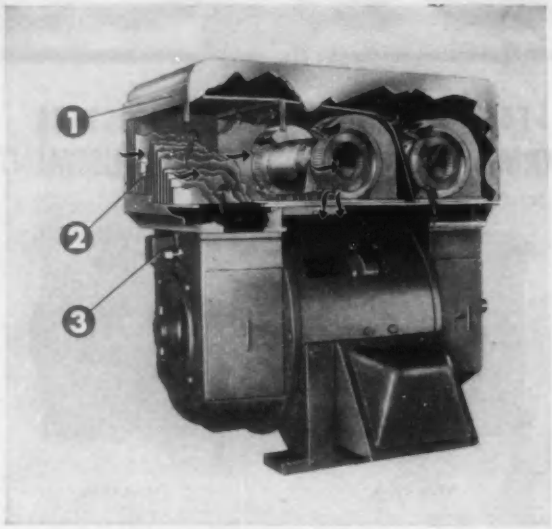
High contact ratings that meet NEMA standards eliminate need for auxiliary relays in most applications. Sturdy construction means dependable operation and extra-long service life. Enclosures help to protect against shocks and vibration. See Bulletin GEA-5921.

New electronic relays have high sensitivity

This new electronic resistance-sensitive relay is able to amplify minute currents carried by very delicate contacts. Even a wet thread will provide enough signal for it to operate.

Sensitivity level is set by adjusting dial, which can be locked in place. The relay may be remotely controlled from as far away as 500 feet. Each can be set for either "normal" (relay "drops-out") or "reverse" (relay "picks-up") operation of the magnetic relay included in the device.

Built for long life, its enclosure is weather-resistant and dust-tight. Terminals are easily accessible; all components of this G-E relay are open for ease in servicing. For further information send for Bulletin GEA-5893.



New G-E Unit-cooled D-c Motor, Small, Compact, Easy to Install—Protected from Dust, Dirt, Grit

General Electric's new totally enclosed unit-cooled d-c motor assures you of dependable operation even in severe atmospheres. It is a completely self-contained unit with no external duct work or air filters to install.

This new motor has two independent air flow systems—one is external (black arrows)—the other recirculates air internally (red arrows). An air-to-air heat exchanger, part of the unit cooler, dissipates heat losses without permitting interchange of air between internal and external circuits.

New ventilation arrangement and special design features of the G-E unit-cooled motor (as shown above) include: (1) COMPACT, top-mounted cooling unit which is within the over-all length and width of the main motor. (2) SELF-CLEANING vertical plates are smooth and need little maintenance. (3) TWO BLOWERS operating the double-ventilation system are powered by separate TEFC motors independent of the main motor speed. This allows the d-c motor to use its full speed range capabilities.

Available in *all* standard ratings from 15 to 200 hp, in constant or adjustable speed types. There is a standard G-E unit-cooled d-c motor ready to go to work for you.

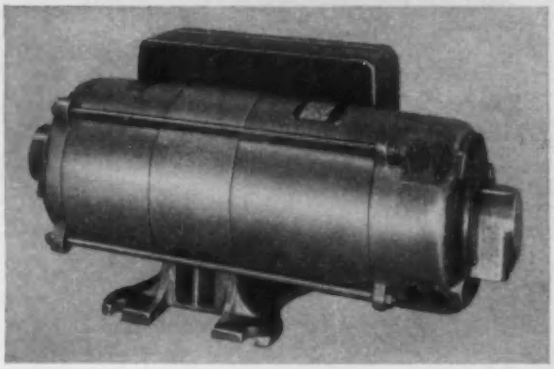
For additional information on this new motor design, send for Bulletin GEA-6091.

GENERAL ELECTRIC

Designer's Digest

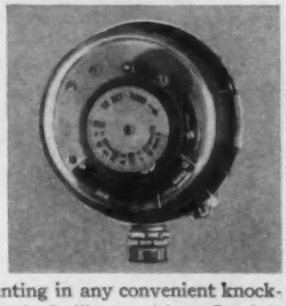
PRODUCT HIGHLIGHTS

G-E AMPLIDYNE GIVES FASTER, MORE VERSATILE CONTROL

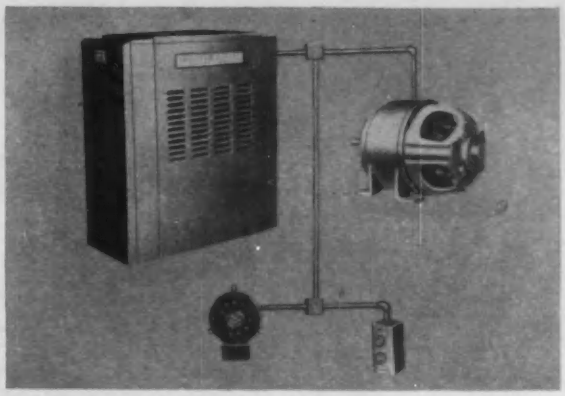


Put the General Electric amplidyne to work for you to improve and simplify machine operation and increase production. It provides fast, accurate control of position, torque, speed, voltage, or tension. Basically, the unique use of a short circuit and compensating winding creates such precise electrical balance that the smallest electric signals release *kilowatts* of output capable of controlling the most powerful machinery. G-E amplidyne assures instant response; full output is reached in 1/10th of a second or less. See the new full-color 24-page booklet "THE AMPLIDYNE—THE SHORT CIRCUIT THAT MOVES MOUNTAINS." Check Bulletin GEA-4053.

G-E PROCESS TIMER CUTS WASTE ON REPEAT CYCLES



On those repeat cycles of opening and closing contacts where percentage of "on" time of double-throw contact must be adjustable, you can cut waste and assure uniformity with a General Electric process timer. Total time cycles, ranging from 10 seconds to 8 hours, are set during manufacture. Percentage of "on" time can be varied by user. Pipe nipple simplifies mounting in any convenient knockout, and flexible color-coded leads facilitate wiring. Conduit arrangements: single pole, double throw. Size: 5 in. in diameter, 3⅛ in. deep. Operates at 25, 50 or 60 cycles, 120 volts or 240 volts. For full description, see Bulletin GEC-525.



Packaged G-E Speed Variator Reduces Installation Expense

The packaged G-E Speed Variator (a-c powered) is customed-engineered for your applications and fulfills all the requirements of a quality Ward-Leonard drive.

Experienced G-E engineers apply the wide variety of Speed Variator features to your particular problems. You get a compact, adjustable speed drive co-ordinated, assembled, packaged, and completely tested in our factory to your requirements, thus reducing your installation costs.

General Electric's Speed Variator gives you all the benefits of increased machine versatility PLUS the dependability of a customed-engineered packaged adjustable speed system. For complete information, check Bulletin GEA-5335.

General Electric Company
Apparatus Sales Division, Sec. A668-113
Schenectady 5, N. Y.

Please send me the following bulletins:

√ for reference purposes X for immediate project

- ☐ GEA-5921 Photoelectric Relays
- ☐ GEA-5893 Resistance Sensitive Relays
- ☐ GEA-4053 Amplidynes
- ☐ GEA-6091 Unit-cooled D-c Motors
- ☐ GEA-5335 Speed Variator
- ☐ GEC-525 Process Timer

CONSULT YOUR SWEET'S PRODUCT DESIGN FILE!

You'll find "everything electric" for machinery manufacturers in the General Electric Section.

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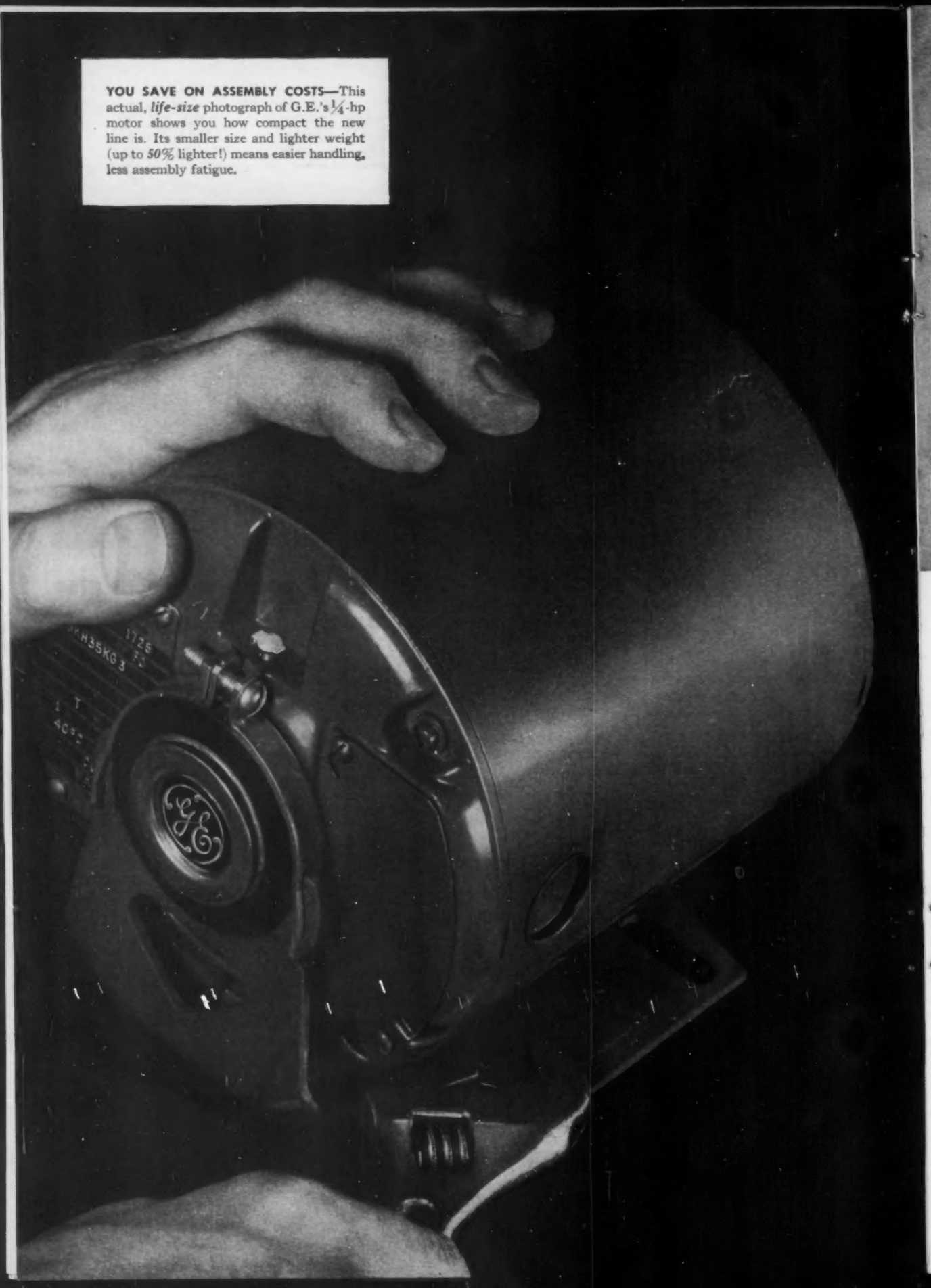
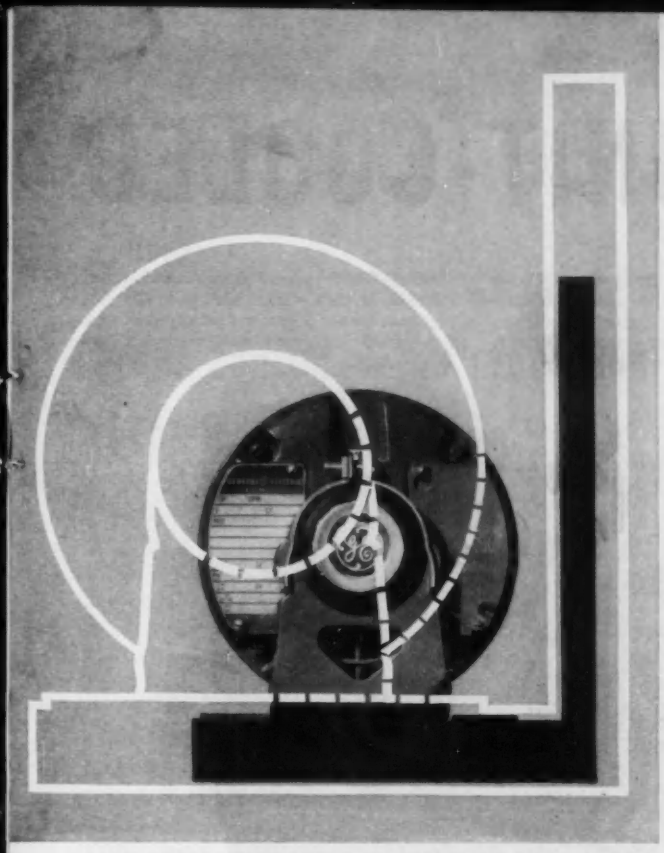
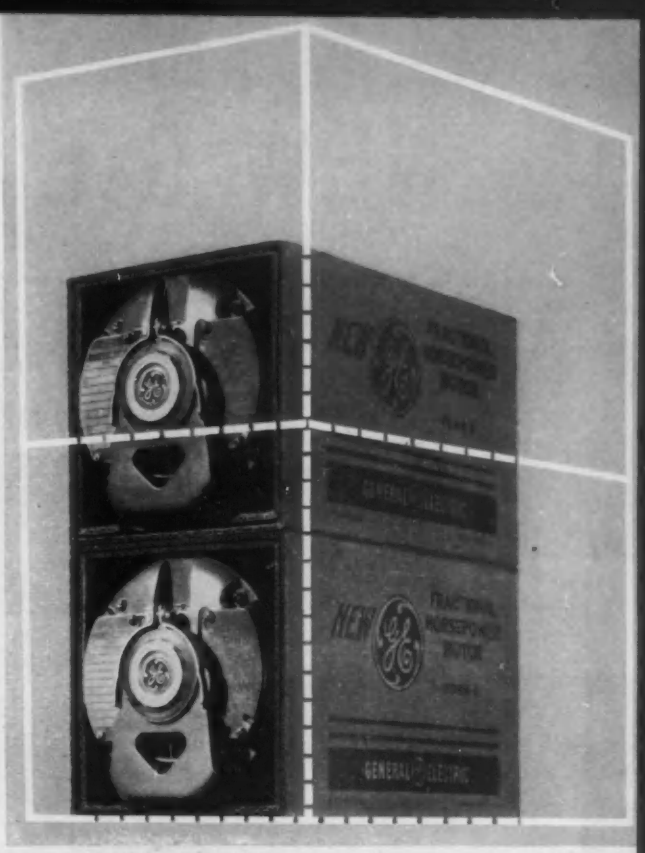


YOU SAVE ON ASSEMBLY COSTS—This actual, ***life-size*** photograph of G.E.'s ¼-hp motor shows you how compact the new line is. Its smaller size and lighter weight (up to *50%* lighter!) means easier handling, less assembly fatigue.



YOU SAVE MATERIAL AND TRANSPORTATION COSTS—Smaller motor size cuts down on mounting space and materials, means lower transportation costs. Lighter weight means less material and lighter mountings. All this brings savings to you!



YOU SAVE VALUABLE WAREHOUSE SPACE—The new G-E ¼-hp motor actually requires 25% less storage space. Other G-E ratings save you as much as 40% in space required for motor stocks, bring you reductions in your material-handling costs.

You save 3 ways by specifying General Electric fhp motors

This general-purpose fhp motor—smaller, lighter, more versatile than ever before—is the basic motor for an entire new line. Oil-burner motors, jet and sump-pump motors, lawn-mower motors, fan and blower motors and others. The savings you get from this basic motor carry through the entire line.

HERE'S HOW YOU SAVE

1—ASSEMBLY COSTS—your assembly line people will find the all-new G-E motor much easier to handle, far faster to install. And "assembly fatigue" . . . caused by handling heavy components . . . will be cut drastically.

2—MATERIAL AND TRANSPORTATION COSTS—structurally lighter mountings can be used. And up to 50% saving in motor weight can cut down your shipping costs.

3—WAREHOUSE STOCKING COSTS. Smaller motor size permits better use of your valuable warehouse space and modern material handling equipment.

WIDER RANGE OF USE

Vastly improved insulation and lubrication system add to the range of your product's applications. The unique all-angle bearing design permits moderate thrust loads in any direction.

When you reorder fhp motors, ask your General Electric Sales Engineer to point out how these savings can benefit your business. Contact your nearby G-E Apparatus Sales Office, or write Section 702-9 for Bulletin GEA-5567. General Electric Company, Schenectady 5, New York.

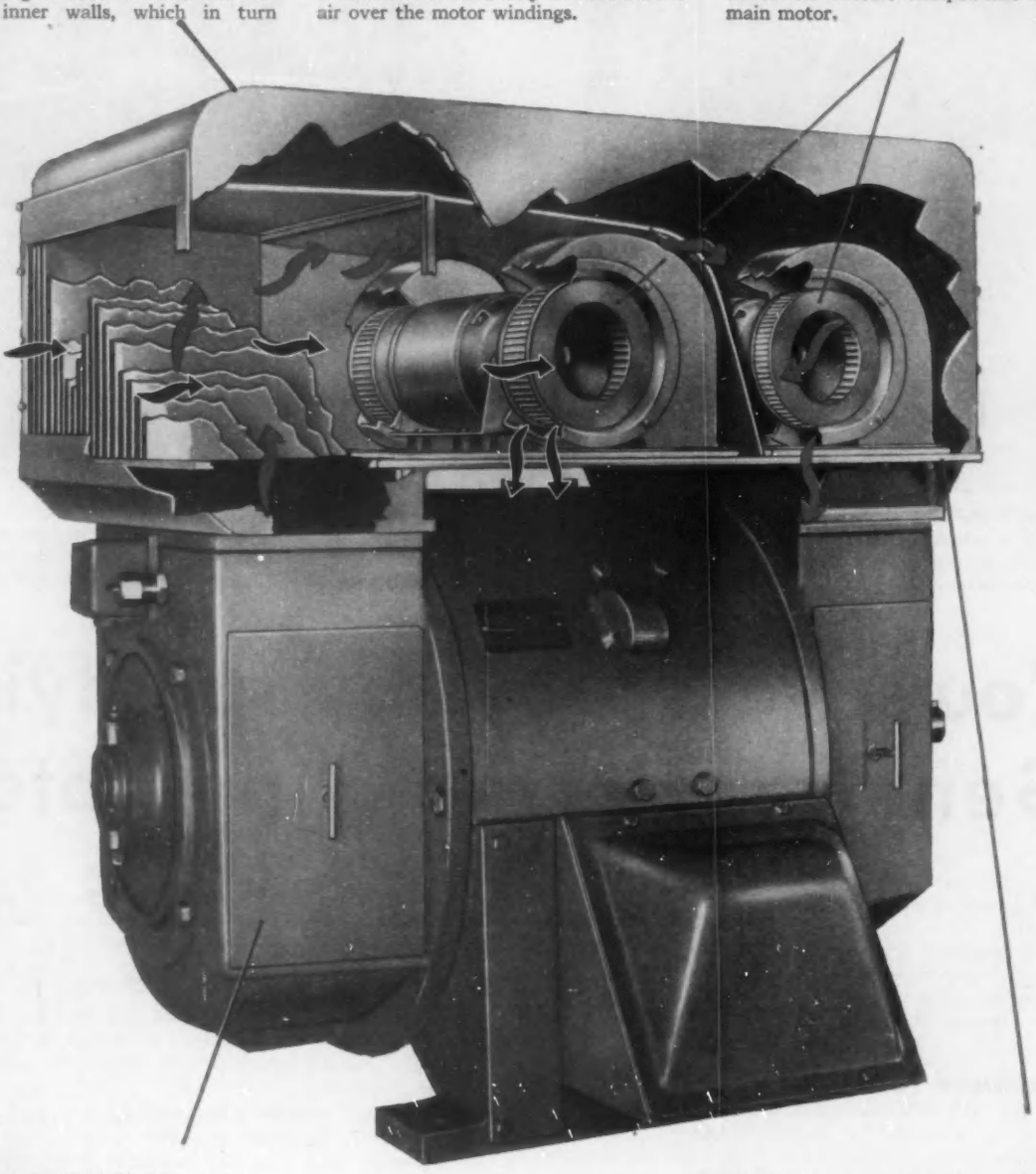
Progress is our most important product

GENERAL ELECTRIC

NEW G-E UNIT-COOLED

DOUBLE VENTILATION SYSTEM: Outside room air (black arrows) enters cooling unit through external portion of the heat exchanger. This air cools the exchangers inner walls, which in turn cool the permanently trapped air. Clean air (red arrows) remains within the unit and never mixes with outside room air. End blower continuously circulates clean air over the motor windings.

TWO BLOWERS operate the double ventilation system and are powered by separate General Electric totally-enclosed fan-cooled motors independent of the main motor.



INSPECTION OPENINGS are gasketed for extra protection. They are easily accessible with no tools required.

COMPACT, top-mounted cooling unit, 37% smaller than previous models, falls within over-all length and width of main motor and is easily removed if necessary.

Progress is our most important product

GENERAL ELECTRIC

D-C MOTOR

Gives you the benefits of d-c speed control — the protection of totally enclosed construction.

WHAT IS THE UNIT-COOLED D-C MOTOR?

It is a Type CD machine with an integrally mounted air-to-air-heat exchanger. Within the exchanger are two separate blower assemblies which operate the unit's double ventilation system. Permanently trapped air cools the motor and in turn is cooled by the outside air being pulled through the heat exchanger.

WHERE DO YOU USE IT?

The new G-E Unit-cooled d-c motor is specifically designed for environments which make open or partially enclosed motors difficult or expensive to maintain. When dampness, metal particles, dust, dirt, oily vapors, fly ash or other harmful airborne materials are present, this new, better protected motor offers real operating economies.

WHAT ARE ITS ADVANTAGES?

WIDE SPEED RANGE OPERATION. Independent ventilation system allows full use of inherent speed ranges of the d-c motor. Ventilation is not dependent upon main motor speed.

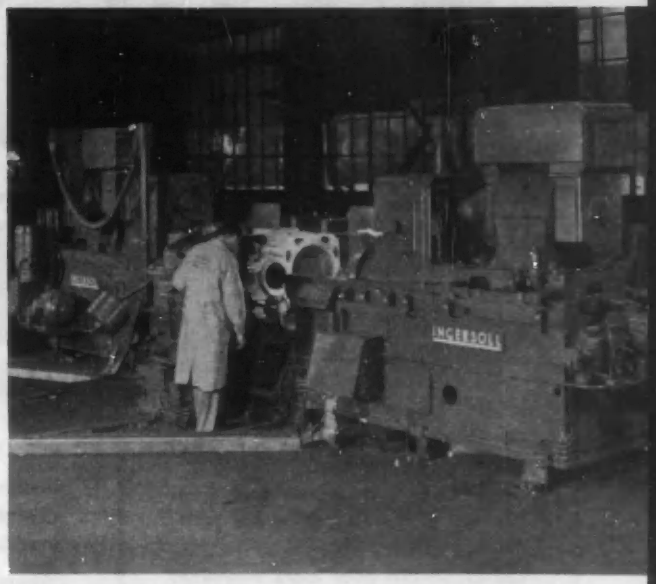
LOWER INSTALLATION COST. Unit has no external duct work, blowers or air filters to install. A completely self-contained unit, it can be relocated or replaced easily and quickly.

LESS MAINTENANCE. There are no air filters to replace or clean. Self-cleaning vertical heat exchanger plates are used instead of horizontal type. Inspection doors are gasketed and easily accessible with no tools needed.

SMALLER SIZE. Unit-cooled d-c motors are built in smaller frames than non-ventilated or fan-cooled motors of the same rating. This gives you smaller size, less weight and lower armature inertia which is important in applications which require frequent and rapid speed changes or reversals.

AVAILABLE IN *ALL* STANDARD RATINGS from 15-200 hp, in constant and adjustable speed types. For more information on the new G-E Unit-cooled motor, contact your nearest G-E Apparatus Sales Office or fill out the attached coupon for a copy of the Unit-cooled motor bulletin. General Electric Co., Schenectady, N. Y.

MOUNTS AT ANY ANGLE. Here two G-E Unit-cooled d-c motors drive a boring machine used for boring diesel engine blocks.



NO DUCTS OR PIPING. Ventilation system of G-E Unit-cooled d-c motor is self-contained. Smooth lines facilitate cleaning.

General Electric Co.
Section D810-1
Schenectady 5, New York

Please send me a copy of Bulletin GEA-6091 on the new G-E Unit-cooled d-c motor.

( ) for planning an immediate project
( ) for reference only

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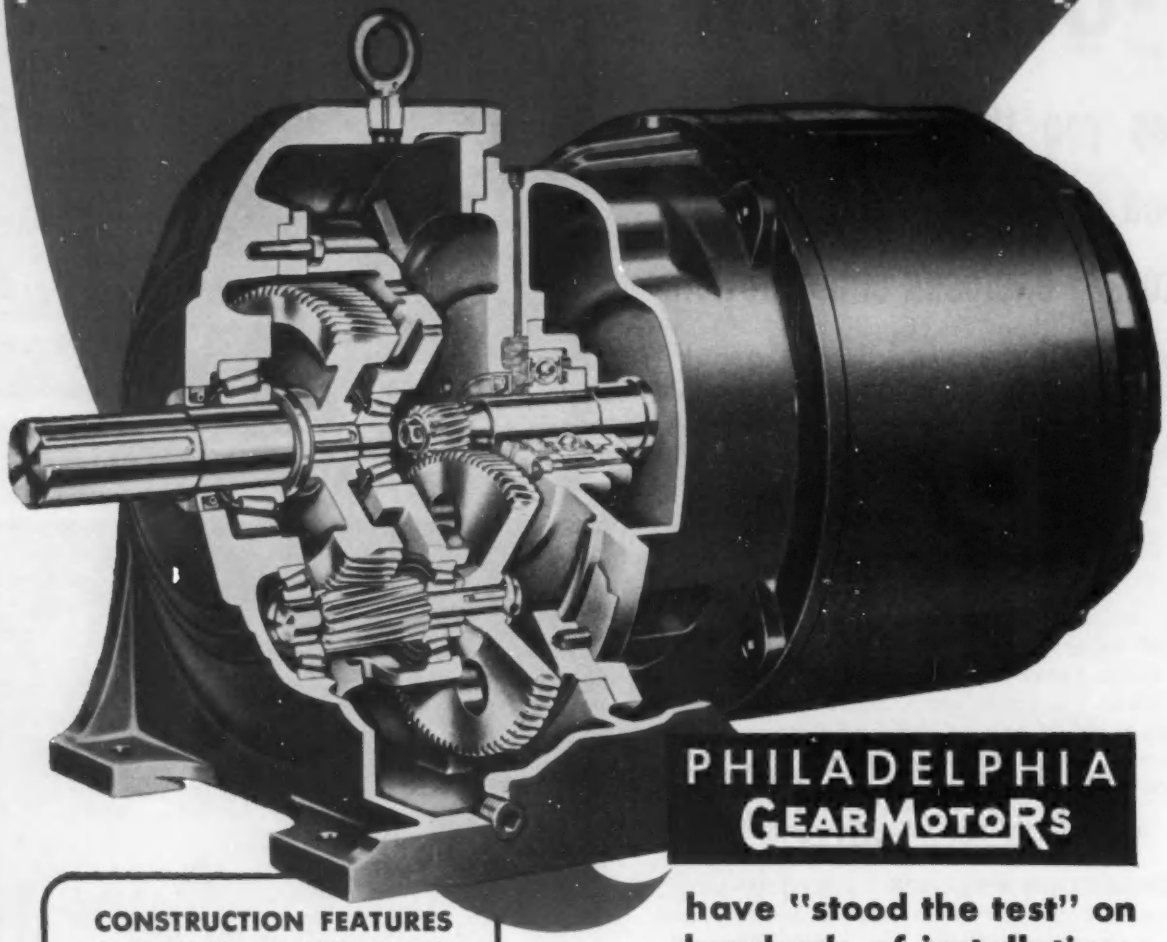
performance IS THE BEST TEST OF leadership



PHILADELPHIA
GEARMOTORS

have "stood the test" on hundreds of installations

CONSTRUCTION FEATURES

Compact without sacrificing strength or accessibility.

Self-Contained Motor and Gear Unit are combined yet readily separated for inspection . . .

Quiet Simple gear train minimizes number of moving parts and promotes quiet operation.

Standardized Construction Interchangeable parts simplify assembly and maintenance.

Prompt Delivery—Most motors in stock.

In almost all branches of industry Philadelphia GearMotoRs are giving the trouble-free service that is proof of their excellent design and precision manufacture.

Where the direct application of electric drive to individual machines is desired the Philadelphia GearMotoR will conserve space and simplify the installation as well as offer definite operating advantages.

They are available in single, double and triple reductions with a speed range from 780 through 7.5 R.P.M. Motor ratings run from 1 HP through 75 HP AC or DC.

Our Catalog GM-48 gives full details.

Philadelphia Gear Works, INC.

ERIE AVE. AND G ST., PHILADELPHIA 34, PA.

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Industrial Gears and Speed Reducers
LimiTorque Valve Controls

Perspectives~ DESIGN AND DEVELOPMENT

CHANGE IN MILITARY RESEARCH

The recent change in U.S. Defense Policy—heavier reliance on aircraft and atomic weapons instead of ground forces—will echo in many research and development programs. The actual number of dollars allotted for military research has dropped only slightly. The big changes are where and how the money will be spent.

In general, research and development funds have been trimmed about five percent, while all defense department spending has been reduced 10 percent. On a dollar for dollar basis, here is how the Eisenhower military budget allots research funds (in millions of dollars):

	1953	1954 (est.)	1955 (est.)
Army	$382.7	$395.0	$370.0
Navy	499.4	475.0	440.0
Air Force	530.2	530.0	510.0
Sec. Defense	—	25.0	30.0
Total	$1,412.3	$1,425.0	$1,350.0

But numbers tell only part of the story. To get the whole picture it is necessary to review some of the individual programs.

CUT ARMY HARDWARE

Army hardware suffered the heaviest cuts. In weapons design and utilization, practically all funds for development of conventional weapons have been diverted elsewhere. There's been internal disagreement and indecision at the Pentagon as to the direction this research should go. Although Army Ordnance has come up with a new rifle and submachine gun, there's no evidence that they are materially better than present weapons. On the other hand, prospects for some unconventional weapons look good. Most military men agree that a man cannot fire a bullet much larger than 0.30 caliber. But he can easily handle—and fire from his shoulder—a 3.5 in. rocket containing two lb of explosive. So, money normally allotted for small arms development is being spent for rocket research.

NO TANK DEVELOPMENT

Tank builders lost almost as much. Tank production funds are 50 percent lower; development money was reduced even more. Plans for bigger, plushier tanks with lower silhouettes, atomic fire-power and better electronics for zeroing in the target have been shelved.

Actually, though there will be no revolution in tank design, some recent innovations will show up in future models. These include tanks that can carry their own bridges, tanks that can fire while being transported across water. But most of these improvements are refinements of existing techniques. There is no money available for development of radical designs.

(Continued on page 125)

THIS MAN PROVES FLEXON BELLOWS BEFORE THEY GO INTO SERVICE

there's no room for guesswork at Flexonics Corporation

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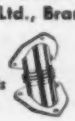
Aircraft components

Metallic bellows

ATOMIC POWER PLANS

Naval development will suffer a heavy reduction in atomic power plants for marine propulsion units. The Nautilus, first atom-powered submarine, is scheduled for test runs later this year. An advanced reactor is being readied for a second submarine, the Sea Wolf. But when that has been launched, development programs will slow down.

General Electric Company, which is building the Sea Wolf's power plant, has another contract to develop an advanced nuclear power plant for submarines, one that would drive the underwater ships at a much higher speed. But, plans to develop a nuclear-powered capital ship have been dropped. Instead, Westinghouse Electric Corporation will build a large scale civilian power generating reactor since much of the technology of the power reactor would be applicable to a large-scale maritime unit.

The Army has plans for a similar unit to produce electricity at some of its high-cost installations abroad. What the Army wants is a "packaged unit"—built in the U.S. and easily assembled overseas at the point of use. It would be a relatively small plant, but still big enough to serve a community of 15,000 people.

Funds for this and other projects like it will have to come from the Atomic Energy Commission. AEC expects to allocate $87 million for reactor development in fiscal 1955. Work on specific reactor designs will constitute 75 percent of the scientific and technical effort. The remainder covers advanced engineering and development.

SPENDING THE MONEY

Bulk of defense research funds will be split between aircraft companies and those engaged in guided missile work. Development of airplanes suited for high subsonic and supersonic speed ranges rates a high priority. The major problem is aerodynamics. The Air Force wants to spend some money for theoretical studies, analyzing air frame failures.

That necessitates some streamlining of air research programs. For instance, the Pentagon has dropped the "stripped-down-fighter." This project was originally developed as a sop to critics who complained that our designs were too complicated; most Air Force leaders were happy to end it for lack of funds, although both Northrup Aviation and Lockheed have such models past the drawing board stage.

THE GUIDED MISSILE RACE

The biggest increase of research and development funds will go to those working on guided missiles—guidance systems, thermodynamics, aerodynamics, servos and control equipment. Virtually every field of technical knowledge is involved in these "push-button" weapons, and the surface has just been scratched. Both private industry and government are pouring money into such projects. While total expenditures are a military secret, it's estimated that close to one billion dollars will be spent on guided missile development in fiscal 1955, another billion for production.

So, despite the changes, Defense Department officials are determined to maintain a broad research and development base. They continue to press for wide dissemination of projects to industry, schools and colleges. And that means only minor retrenchments for scientists and engineers.

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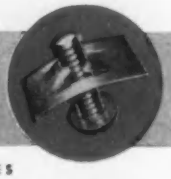


MORE THAN 8000 SHAPES AND SIZES

We Are Not Independent

MEN OF HIGH INITIATIVE, intelligence and industry are often irked by the restraints imposed upon them by traditions and the dictates of social customs. If their feelings get too intense, they are in danger of developing the mental attitude of the soldier boy who claimed that he was the only one in the regiment who was in step. The fact was that he had started off on the wrong foot.

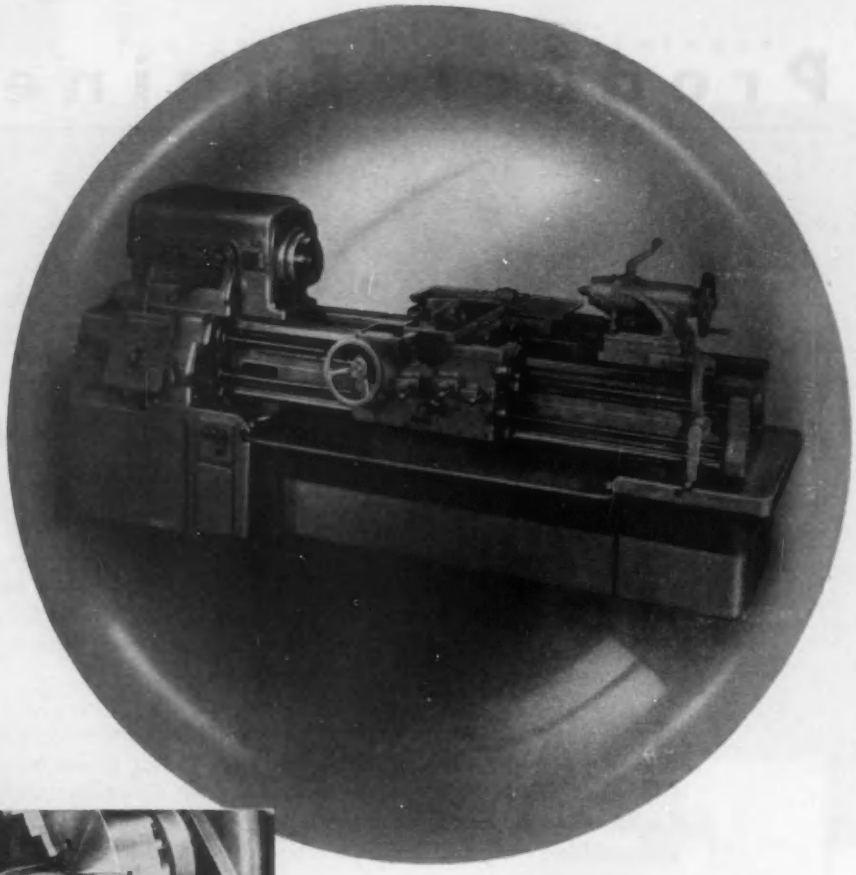
In the world of science, with its basis of physical laws and rigid mathematical relationships, tradition or social customs cannot prevail long against hard facts and cold mathematics. But in engineering we must accept the dictates of society, the customs of industry and the resistance to change. Progress is usually a slow plodding wherein "give and take's the gospel, and we'll call the bargain fair".

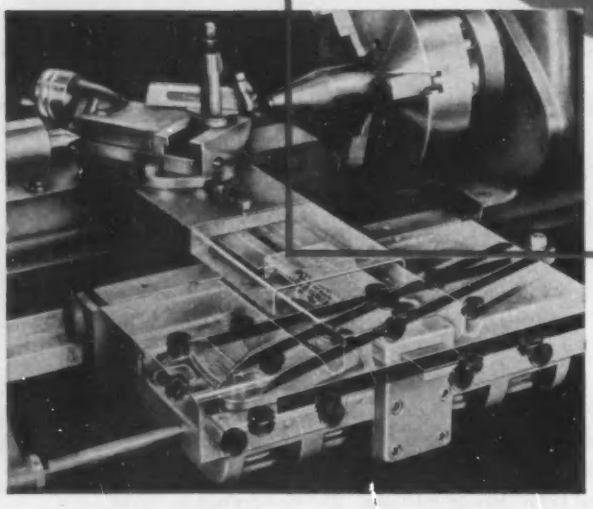
There is practically nothing in this world that cannot be improved upon. Indeed, if one were to attempt to list everything that "should be improved" and then get real serious about it, the final result would probably be insanity. Even nature itself will not accept perfection. Perfectly pure water will not boil no matter how it is heated. It bumps. Humans who insist on perfection don't get "boiling mad" when "hot under the collar". They bump. Often they bump so violently that they unbalance some of those with whom they come in contact. But ever present stalwarts with firm footing and steady hand keep things running on an even keel.

There is always a strong temptation for the engineer who is sponsoring a new development to clothe it with superlatives and expect universal acceptance. Actually, the qualities are not superlative and rarely, if ever, does the development have universal application. Every human accomplishment can be improved upon, and there is no cure-all for the many difficulties, problems and ills that befall human activities. He who dedicates himself to the relentless struggle for universal acceptance of his "perfect" creation will soon find himself to be the only man in the regiment who is in step. In his conviction that his brain child is ideally perfect, he will become sadly bruised as he bumps his way along, vainly trying to get the world to adopt his self appraised masterpiece.

George F. Zook

BALL BEARINGS make a product BETTER





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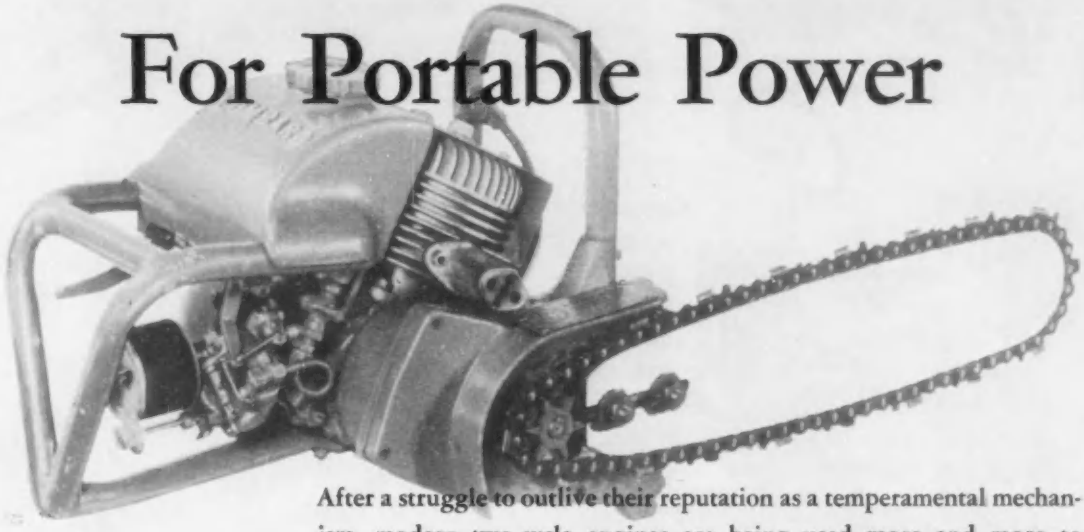
Two-Cycle Engines For Portable Power



After a struggle to outlive their reputation as a temperamental mechanism, modern two-cycle engines are being used more and more to power small portable equipment. Presented here are the details of operating principles, engine design factors, performance characteristics and engine selection factors for air-cooled portable two-cycle units.

ROBERT G. KRUEGER
Vice President, Power Products Corporation, Grafton, Wis.

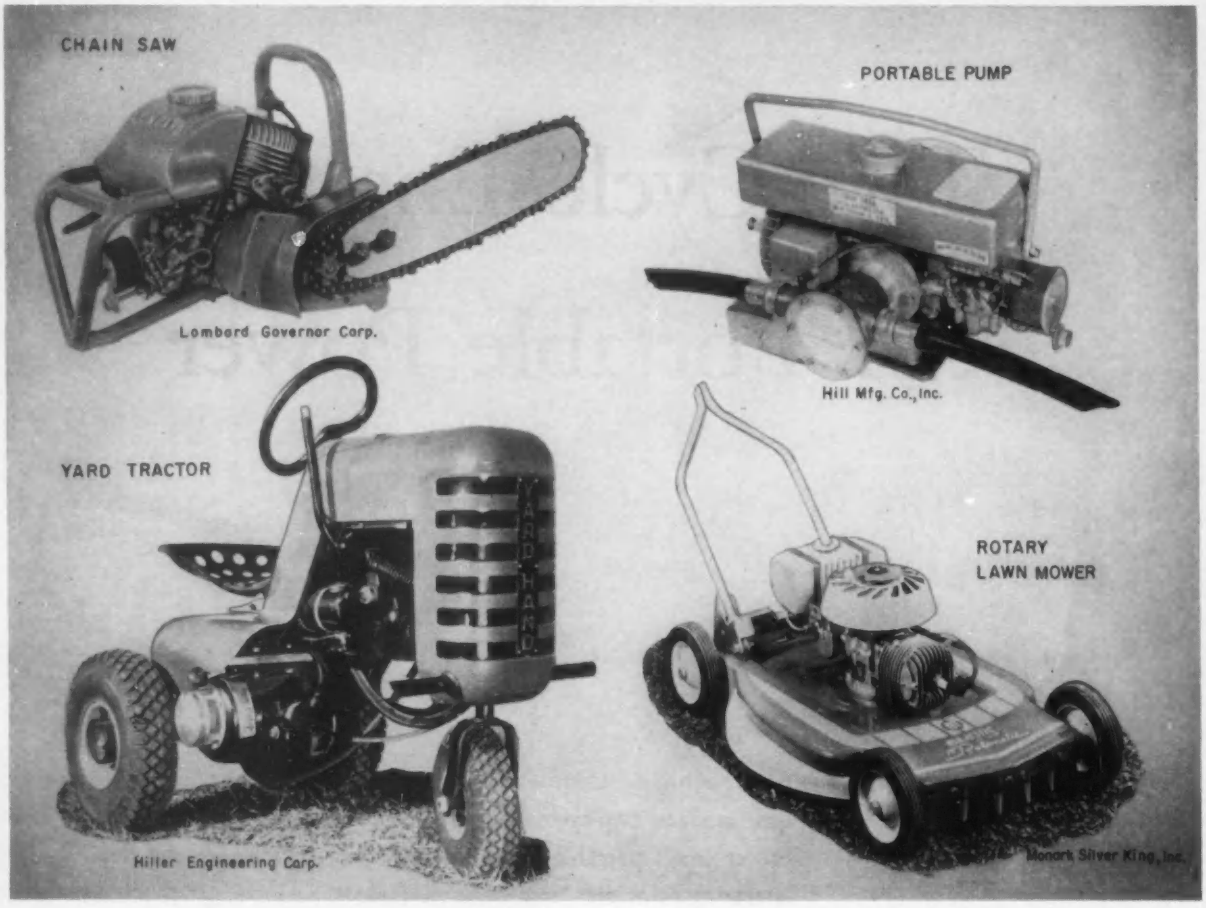
LIGHT WEIGHT, easy starting and reliable performance have resulted in the modern two-cycle gasoline engine being used to power many types of portable equipment. Typical applications are those where the machine must be lifted, carried, moved frequently or operated in a variety of positions. These include rotary and reel type lawn mowers, chain saws, outboard motors, water pumps, air compressors, small tractors and electrical generating equipment.

A two-cycle engines produces one power stroke for every revolution of the crankshaft while a four-cycle engine produces one power stroke for every two revolutions. Thus, for the same speed and power the torque per explosion is less in a two-cycle engine, and lighter-weight connecting rods, pistons and crankshafts can be used. In addition, the two-cycle unit does not require a cam shaft, gears, valves and valve mechanism and a lighter flywheel can be used because of the greater frequency of power strokes. These characteristic features plus the use of aluminum and magnesium in many of the major parts have given the two-cycle engine a low weight per horsepower rating. A comparison of typical two- and four-cycle engines is given in the following table.

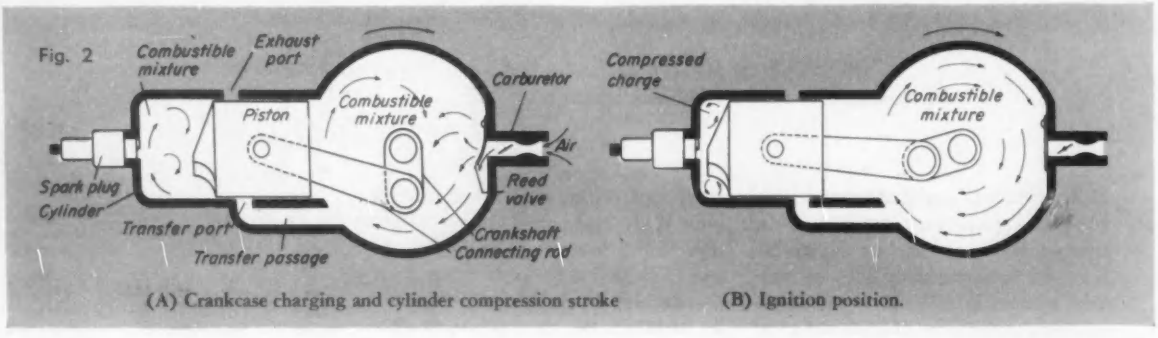
Engine Type	Weight, lb	Speed, rpm	Rated hp
Make "A" two-cycle	14¾	3,600	2
Make "B" four-cycle	33	3,600	2
Make "C" four-cycle	35	3,600	2

Commercially available two-cycle engines, Fig. 1, vary in size from about 1 to 3½ hp. One or two cylinders are used depending on the rating. Since most of these engines are air cooled (with the exception of outboard motors for marine use and a few water pump applications) the following discussion will be limited to this type.

TYPICAL APPLICATIONS OF TWO-CYCLE GASOLINE ENGINES



SEQUENCE OF OPERATIONS OF TWO-CYCLE ENGINE



(A) Crankcase charging and cylinder compression stroke

(B) Ignition position.

Operating Principles

In Fig. 2, (A) to (D), is shown the various operating positions of a typical two-cycle engine. As the crankshaft rotates, the piston moves toward the top of the cylinder creating a partial vacuum in the crankcase, (A). Atmospheric pressure then forces air into the carburetor and the resultant combustible mixture flows through the reed valve into the crankcase. This continues until the piston reaches the top of the stroke, (B), where the flow stops and the reed valve shuts.

When the piston starts down, the combustible mixture is compressed in the crankcase, (C), until the piston approaches the bottom of the stroke. At this point the piston uncovers the

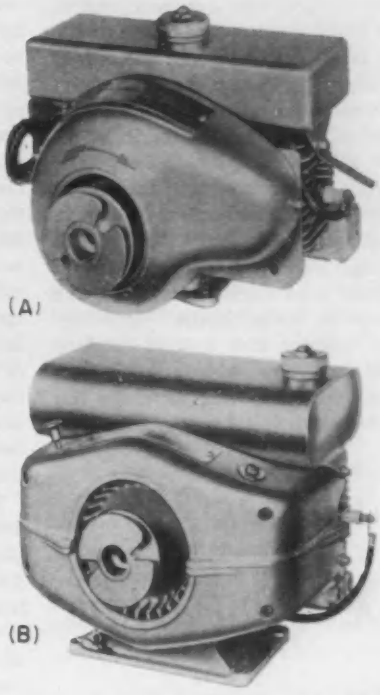
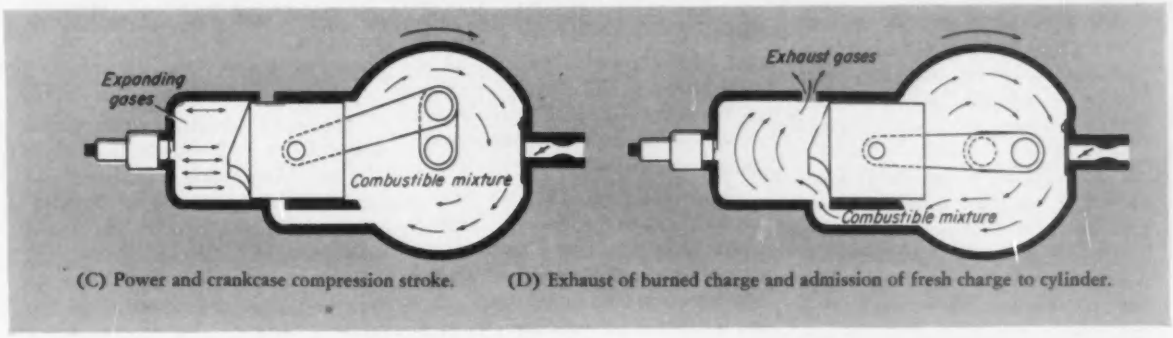


Fig. 1—Two types of small two-cycle engines for use on portable equipment. Unit in (A) is single cylinder, shrouded fan type with horizontal shaft. It will develop about 1.1 hp at a governed speed of 3,300 rpm. Two-cylinder unit in (B) is similar and will develop about 2 hp at a speed of 3,300 rpm. (A) weights 16½ lbs and (B) 23 pounds.



(C) Power and crankcase compression stroke. (D) Exhaust of burned charge and admission of fresh charge to cylinder.

transfer ports allowing the charge to pass through the transfer passage and into the cylinder, (D). The piston then moves up in the cylinder, closing the transfer ports and compressing the charge in the cylinder. At the same time a fresh charge is drawn into the crankcase. As the piston reaches the top of the stroke, (B), a spark ignites the compressed mixture. This forces the piston down and compresses the new charge in the crankcase, (C). When the piston approaches the bottom of the stroke, the exhaust ports open allowing the burned gases to escape. The transfer ports are immediately uncovered and the new charge that has been compressed in the crankcase flows through the transfer passage and ports and into the cylinder helping to expell the burned gases. The piston then starts its upward stroke and the process is repeated. Thus, one power stroke is produced for every engine revolution.

Since the two-cycle engine is lubricated with oil pre-mixed in the gaso-

line it is not necessary to have an oil sump or reservoir and these engines can be operated in any position without major design changes. It is only necessary to change the position or location of the carburetor. In addition, floatless diaphragm carburetors are now available that allow an engine to operate in any position. Fuel is delivered to these carburetors by pressurizing the gas tank from the crankcase through a check valve.

Most small engines are started with a rope or rewind starter. Since two-cycle engines have a small displacement combined with a lighter flywheel, lighter moving parts, and low inertia, the required starter pull is low.

Engine Design Factors

The basic component parts of a two-cycle engine are the crankcase, crankshaft bearings, connecting rods, pistons, cyclinders, mixing valve or carburetor, air filter, governor, cooling system, and the valving, Fig. 3. Although many of these parts are more or less standard regardless of engine application, the type and construction of certain parts depends on such application factors as speed, speed regulation and load.

The crankcase is usually die cast in two parts; split along the centerline of the crankshaft or along the centerline of the cylinder. Bronze or antifriction bearings are cast, pressed or shrunk in place. Machined surfaces are provided to accept the cylinder, carburetor, magneto stator plate, engine base and driven accessories such as pumps, generators, gear reducers, clutches, and transmissions. Since two-cycle engines can be operated in any position, the location of the carburetor is determined by engine application. Many crankcases are designed so that by rotating the carburetor through 90 deg the same basic case and engine can be used for vertical or horizontal applications.

Crankshaft Bearings

Either bronze, needle or ball bearings are used to support the crankshaft in small two-cycle engines. Bronze bearings can be used when the speed and engine load are low. However, because of the mist type of lubrication it is frequently difficult to properly lubricate a bronze bearing engine. This is particularly true where the bearings must be relatively long to support the load. If proper clearances are maintained between the crankshaft and the bronze bearing it is difficult to lubricate the outer end of the bearing. In contrast, if the clearance between the bearing and the crankshaft is increased to the point where ample lubrication can reach the outer end of the bearing, the problem of sealing the crankcase becomes more difficult since the seal wears rapidly because of the excessive radial movement of the crankshaft.

Worn or leaky seals will produce erratic engine operation since they cause leakage during the induction stroke. This factor contributed to the temperamental reputation of earlier two-cycle engines. Instead of drawing all of the charge through the carburetor, fresh air is drawn directly into the crankcase through the seals, diluting the charge and causing the engine to run lean. This leakage would not be too serious if a constant condition could be maintained since the carburetor could be adjusted to compensate for it. However, if the engine is started cold, the oil that has accumulated in the bearings serves as a partial seal. Under these conditions, the carburetor is set for proper operation. As the engine warms up, oil viscosity decreases and more air leaks into the case. This requires readjustment of the carburetor. Satisfactory operation of the engine cannot be maintained if the quality of the mixture delivered to the cylinder varies.

Bronze bearings are also limited in their end-thrust bearing capacity. Unless some provision is made for the circulation of oil through the bearing when it is subjected to end thrust (such as complicated oil grooving), the bearing against which the crankshaft is riding will be starved for oil.

Needle bearings are better than bronze bearings for two-cycle engine service. They have long life, are easy to lubricate and do not permit as much radial movement as bronze bearings. However, needle bearings have no provision for taking end thrust and must always be supplemented by some type of thrust bearing.

In contrast to bronze and needle bearings, ball bearings have small radial clearances, are well suited to mist lubrication and can absorb relatively high end thrusts. In a typical engine the bearing outer race is shrunk into the crankcase and a light press fit is used between the crankshaft and the inner race. With this construction, radial movement of the crankshaft is negligible and long and consistent seal performance can be obtained.

Another feature of ball bearings is the ease of replacement. The shrink fit insures accurate realignment of new bearings. With bronze bearings, the worn bearing must be bored or pressed out and the new ones pressed in and reamed.

Connecting Rods

Two types of connecting rods are used depending on the speed range. For operating speeds below 4,000 rpm, rods with bronze or aluminum bearing surfaces are satisfactory, Fig. 4 (A). The sand cast or forged bronze rods are made of alloys with suitable bearing surface characteristics, while some engines use die cast aluminum rods with bronze inserts at both ends.

For higher speeds and heavier duty applications, forged steel rods with needle bearings at one or both ends are used, Fig. 4 (B). This type of rod usually has a needle bearing cartridge on the piston pin end, while the crankshaft end has needles interposed between the crankshaft, which serves as the inner race, and the connecting rod, which serves as the outer race.

Pistons

The most commonly used piston shape has a baffle on the top which deflects the incoming fuel charge and directs it toward the top of the cylinder to clear the cylinder of burned fuel remaining from the previous explosion (see pistons in Figs. 2 and 3). The height and configuration of the baffle is dependent upon the size, speed and load carrying characteristics desired in the engine.

Some engines have been built with a flat top piston. When this shape is used it is usually necessary to extend the porting further around the circumference of the cylinder and to shape the intake ports so that they direct the incoming fuel charge toward the top of the cylinder to effect satisfactory scavenging. If normal porting is used

the charge would flow straight across the flat top piston and would not clear the top of the cylinder of burned fuel. The flat top piston, because of the absence of any protruding baffle, is considered easier to cool while the piston with the baffle on top gives better scavenging.

The number of rings used depends upon engine speed and compression pressure. Pistons have two, three or four rings. The rings may be free to rotate or they may be pinned.

Cylinders

The cylinders of most small two-cycle engines are made of die cast aluminum with a cast iron sleeve or liner cast in. Cylinder sleeves can also be pressed or shrunk into place. The type of cylinder fins used is selected from the standpoint of proper cooling for the horsepower produced.

The cylinder ports can be cast or machined. If square ports are used (for higher horsepower units) they are usually cast in because of the saving over machining a square opening. Round ports can be more accurately located, and are usually machined.

Where high output is required, chrome plating can be used. The aluminum casting is machined to within 0.002 to 0.004 in. of finished size and the cylinder plated in the bore. Chrome plating increases the ability of the cylinder to dissipate heat, and is lighter than a cast iron sleeve.

Mixing Valves and Carburetors

The mixing valve is a device that mixes air and fuel in the proper ratio and meters the mixture into the crankcase. Basically it consists of a spring loaded poppet valve that operates once during each revolution of the engine. The lifting action is produced by the difference between the partial vacuum in the crankcase and atmospheric pressure. A fuel inlet orifice is located under the seat of the poppet valve with a needle valve to adjust the flow of fuel to the inlet orifice.

The mixing valve was used successfully on low speed engines, particularly under conditions of reasonably constant load and speed. However, with the development of high speed engines that operate above 7,000 rpm, the mixing valve is not generally used since poppet valves are not available that will operate at these high frequencies.

Most two-cycle engines now have carburetors similar to those used in the automotive industry, Fig. 5. Typical carburetors have a throttle control, a choking arrangement, and a high and low speed jet system. With the increased use of air filters, it has also become necessary to build into the carburetor an equalizing system which will assure a uniform fuel-air mixture ratio regardless of dirt accumulation in the air filter.

A recent development has been the application of diaphragm carburetors on two-cycle engines. In these carburetors the conventional float and float chamber is replaced with a diaphragm actuated by pressure from the crankcase. A closed fuel system, pressurized from the crankcase, is used so that fuel is delivered to the carburetor re-

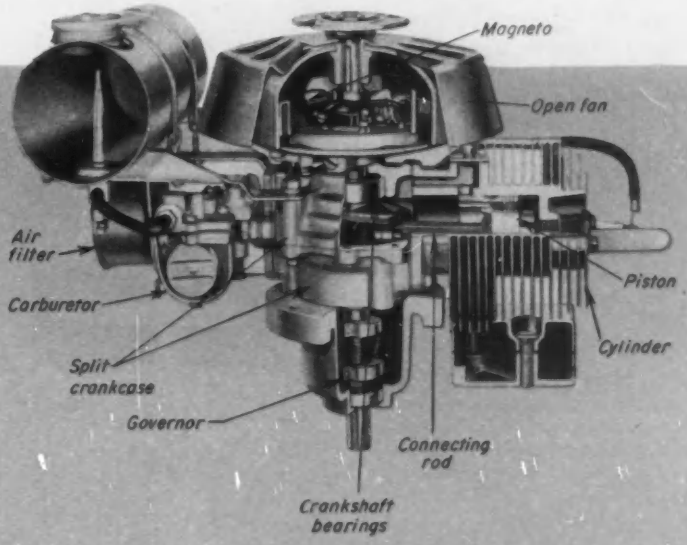


Fig. 3—Cut-away view of single cylinder, vertical shaft engine with open type fan. Unit weighs 14 lbs and with dry type filter and exhaust muffler (as shown) will develop about 1 hp at a governor setting of 3,300 rpm for full load operation.

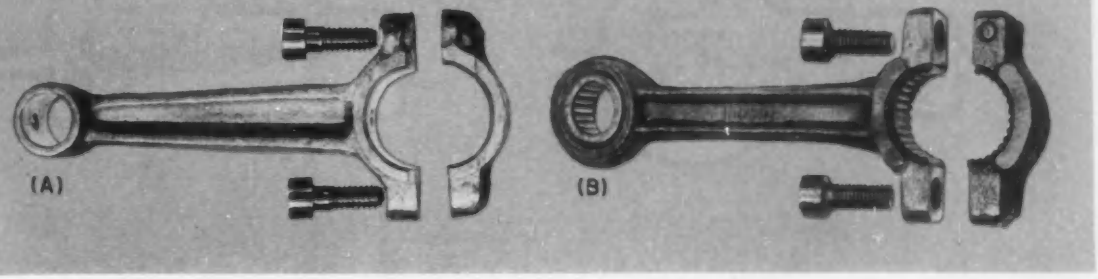


Fig. 4—Bronze (A) and forged steel (B) connecting rods for two-cycle engines. Bronze rod has bearing surfaces machined directly in rod material. Forged steel connecting rod uses cartridge type needle bearing on the piston end and uncaged needles on crankshaft end.

gardless of its position in relation to the fuel tank. With this arrangement the engine can be operated in any position.

Air Filters

Air filters used on two-cycle engines include the oil-bath type and the dry type. While both types of filters are about equally efficient in cleaning the air, the oil-bath filter is limited to those applications in which the engine is always run in the same position. Since portability is usually one of the principal reasons for using two-cycle engines, they are generally equipped with the dry type filters.

Governors

Engines operating at a regulated speed use either air-vane or fly-ball type governors. The air-vane governor has the advantage of simplicity and lower cost. However, since it must be located in the air stream of the engine cooling system, it is subjected to dirt, dust, and other foreign materials that are drawn in by the fan. The vane type governor has a poor regulating characteristic since it governs in accordance with the velocity of the air blowing past the air-vane. This velocity is determined by the speed of the engine but it can be appreciably affected by dirt and particles of foreign material that collect on the air inlet screen and within the air duct leading to and surrounding the vane. In addition, any dirt and other foreign material that collects on the air-vane or the actuating linkage will affect the operation of the unit.

Fly-ball type governors give better regulation because they are usually completely enclosed in a dirt and dust

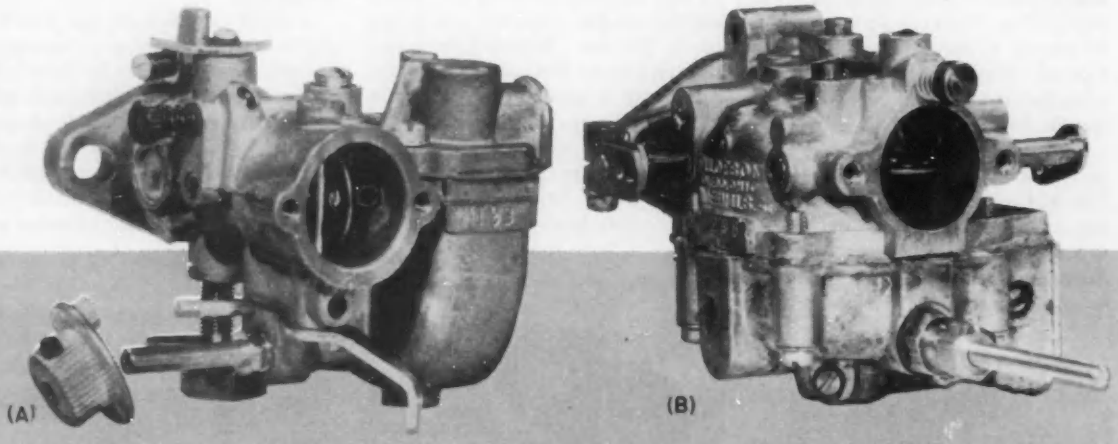


Fig. 5 (Above)—Two typical float type carbetors. (A) shows side bowl unit and (B) concentric bowl unit. These units are satisfactory when engine will not be tilted more than an allowable maximum number of degrees from vertical.

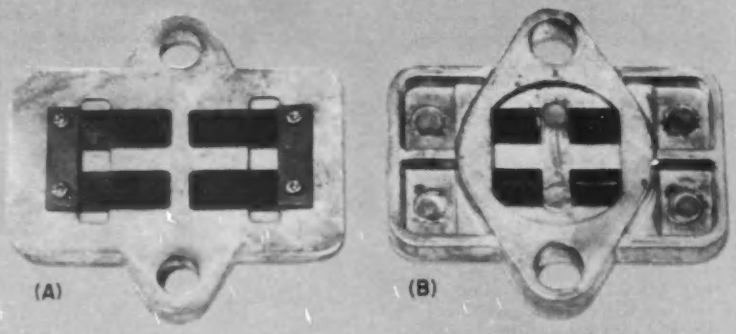


Fig. 7—(Right) Reed plate valve from crankcase side (A) and carburetor side (B). Valve unit should be as close to crankcase as possible and is usually secured directly to it.

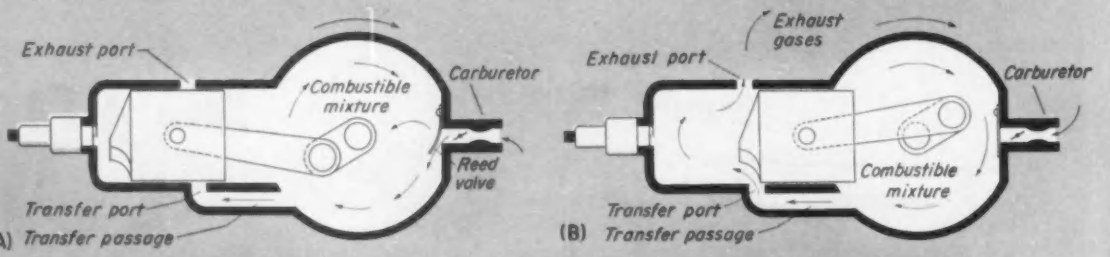


Fig. 8—Reed valve type induction system on crankcase intake portion of stroke (A) and cylinder charging portion of stroke (B). Reed valve gives efficient valving since timing varies with engine speed and load.

free compartment and their operation is affected solely by the speed of the engine.

Cooling Systems

The cooling system of small air-cooled engines consists of either an open or a shrouded fan depending on environmental conditions and load. The first system employs an open type fan (die cast or formed from sheet metal) mounted on one end of the crankshaft, Fig. 3. The tips of the blades are joined by a rim that serves as a guard for the blades and is shaped to confine the air flow and direct it toward the engine. This arrangement is not efficient since a considerable portion of the air it handles is thrown beyond the engine or onto parts that do not require cooling. However, the open fan is relatively inexpensive and is suited to installations such as lawn mowers where the air around the engine is filled with grass clippings or similar foreign material. The open fan will throw off the foreign material and the cylinder fins, being free of shrouding, are not easily clogged.

The shrouded cooling system is made up of a centrifugal type fan, also mounted on one end of the crankshaft, but enclosed in a spiral shroud which extends to, and fits closely around, the cylinder, Fig. 6. This system is more efficient than the open fan as the shroud causes all air moved by the fan to pass directly over the cylinder fins. The shrouded fan is best suited to engines that must run at high speeds and under relatively heavy loads where maximum cooling is required and where the ambient air is reasonably free of foreign material.

Valving

Reed valves, rotary valves and third port valving are used to control the flow of combustible mixture into the crankcase. The reed valve consists of a plate with one or more openings each covered with a thin metal reed secured to the plate at one end, Fig. 7. The reeds are actuated by the difference

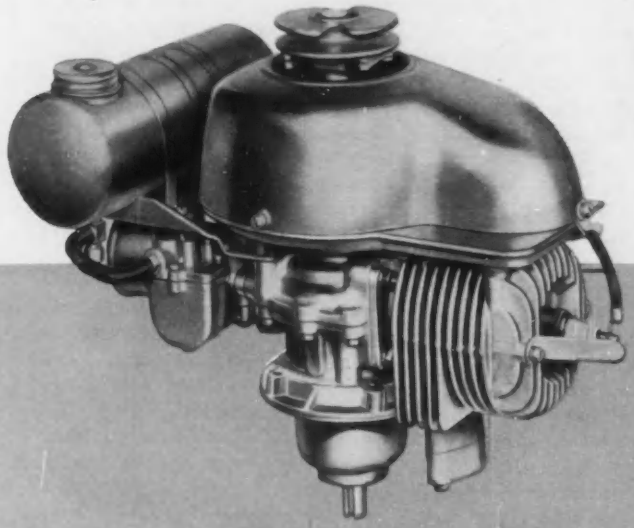


Fig. 6 (Left)—Vertical shaft, single cylinder engine with shrouded fan. Shroud directs entire output of fan down around cylinder and crankcase. This arrangement is best except when surrounding air is filled with foreign material that can foul the fan blades.

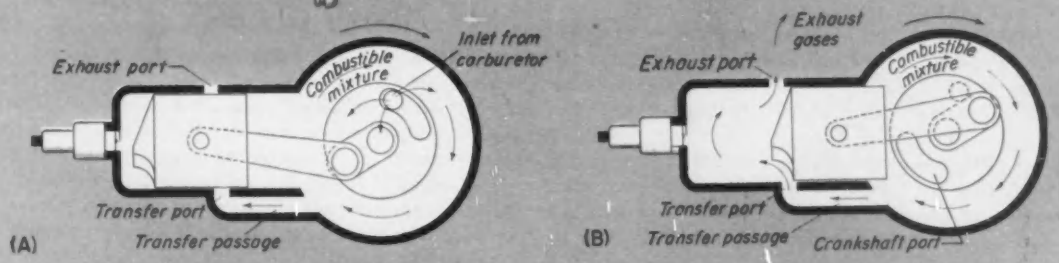


Fig. 9—Rotary valve induction system. (A) shows crankcase intake position and (B) shows cylinder charging position. Engines with rotary valves have fixed timing and will not operate at maximum efficiency over a wide range of load and speed.

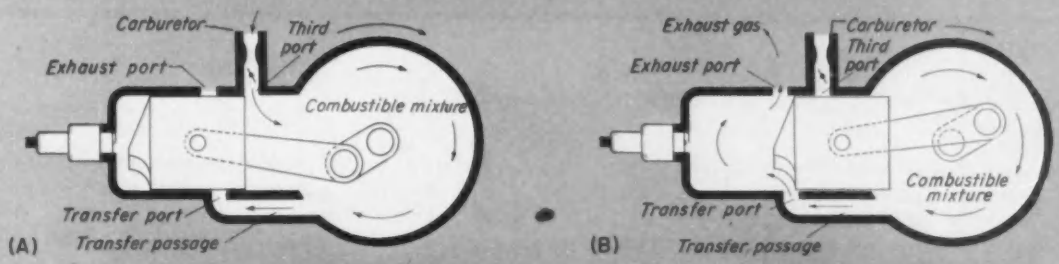


Fig. 10—Third port induction system. During crankcase intake, (A), the piston skirt uncovers the third port in the cylinder and admits the combustible mixture. During crankcase compression and cylinder charging, (B), the port is closed.

in pressure between the crankcase and the carburetor and thus do not open and close in a fixed relation to the angular position of the crankshaft. Instead, because the differential pressure between the crankcase and the carburetors varies with the speed and load, the timing of the reed valve also varies with these factors resulting in efficient valving throughout the entire range of loads and speeds, Fig. 8. This type valve is not affected by wear.

One type of rotary valve, Fig. 9, consists of an elongated port in the crankshaft that operates with a port in the crankcase. At the proper time the rotating port coincides with the opening through the crankcase and allows the fuel mixture to pass from the intake system through the valve mechanism into the crankcase. The rotary valve furnishes a positive mechanical device for charging the crankcase. However, the timing of the rotary valve is fixed in relation to the angular position of the crankshaft. It cannot compensate for a variation in load or speed of the engine. If an engine is to be operated at a constant speed and load, the rotary valve can be timed to give the best efficiency under these particular conditions. However, it is difficult to get a rotary valve to operate efficiently through the entire possible range of speeds and loads under which a two-cycle engine may be called upon to perform. In addition, valve operation is affected by bearing and crankshaft wear.

The third port type of valve consists of a third port in the cylinder, Fig. 10. In addition to the intake port and the exhaust port, that are present in all small two-cycle engines, there is a third port located further down the cylinder wall. The outward moving piston produces a partial vacuum in the crankcase. Near the end of its outward stroke the skirt of the piston uncovers the third port which is connected to the carburetor. Atmospheric pressure forces a charge of air and fuel from the carburetor through the third port into the crankcase. As with the rotary valve, the third port engine has fixed timing and cannot be made to operate efficiently through a wide range of loads and speeds. The third port is also affected by piston and ring wear and the accumulation of foreign material in the port itself.

Performance Characteristics

In Fig. 11 is shown typical horsepower curves for a standard industrial two-cycle engine. Curve *A* represents output without an air filter or muffler, while curve *B* represents the output of the same engine equipped with a filter and muffler. There is a horsepower output reduction of approximately $\frac{1}{3}$ horsepower caused by the addition of these accessories. There is also a difference in where the two curves peak; curve *A* peaks at 4,400 rpm and curve *B* at 3,800 rpm. The lower curve is typical of that obtained with a standard commercial muffler. If extremely quiet operation is required a muffler with more back pressure must be used and the curve will peak at a still lower speed.

The maximum horsepower and the point at which it occurs are also affected by such factors as carburetor venturi size, ignition timing, port area and compression pressures.

Up to a certain point the power output of an engine is dependent upon the carburetor venturi size. The maximum size that can be used depends upon the speed range through which the engine must operate. If an engine is never operated under full load conditions below 3,600 rpm maximum power might be obtained with a venturi size of $\frac{3}{4}$ in. However, if this same engine must operate under full load at 2,600 rpm, a smaller size venturi, possibly $\frac{5}{8}$ in., must be used. This is necessary because at 3,600 rpm and with a $\frac{3}{4}$ in. venturi the velocity of the air past the carburetor jet is adequate for proper operation, while it is not adequate at a speed of 2,600 rpm. At this speed the mixture is "leaned out" and the engine loses power or even stops. Therefore, the venturi size of the carburetor is not determined by the peak horsepower, but rather by the lowest speed at wide open throttle at which the engine must run. This should not be confused with partial throttle opening at lower speeds. Under this condition the idle intermediate jets give the proper mixture ratio at lower speeds.

Ignition timing is another factor that determines the maximum power and the speed at which it peaks. Any engine should be operated with the spark advanced as far as possible. The degree of advance that can be used, especially on an engine running at a speed of 5,000 rpm or higher depends on whether or not it can be started at cranking speed without "kicking

Engine Selection Factors

1. Required Horsepower. The horsepower required must be known so that the proper size engine can be selected. While two-cycle engines can operate at full load for long periods it is best to select an engine that has at least 20 percent more power than the maximum power required for the application. This additional power is necessary to take care of variables such as temperature, altitude, variations in the driven unit and the engine.

2. Operating Speed. Since horsepower output varies with speed, this factor is closely associated with selecting an engine with the proper rating at the correct speed. A knowledge of the operating speed will also permit the selection of the most economical type of rod bearing. For speeds below 3,600 rpm plain or bronze bearings are satisfactory, for speeds above 3,600 and particularly above 4,000 rpm anti-friction bearings should be used.

back." Two-cycle engines can run at high speeds developing maximum power with the ignition timing set as far ahead as 35 to 40 deg before top dead center. However, engines so timed, particularly the larger ones, cannot be started without inconvenience to the operator or damage to the starting mechanism. In addition, ignition timing with that much advance causes a rapid loss of power as the speed is brought down as a result of increased load.

The area of the ports in a two-cycle engine also affects maximum output. This is particularly true of the exhaust ports since they must allow the escape of the expanded burned charge. If round or drilled ports are used they should be as large as possible without reducing the effective stroke of the engine. Squared ports give greater area for the same maximum dimension, but the cost of production is higher. With either shape it is necessary to space the ports so that the bridge of metal between them has enough mass to conduct the heat to the main body of the cylinder. Excessive burning of the bridges will result if they are too narrow. The size of the ports cannot exceed the distance over which the piston rings can travel without dropping into the openings. If the piston rings are pinned so that the ends cannot pass over the port openings larger ports can be used. However, pinned rings are more susceptible to varnishing and sticking.

The power output of an engine increases with an increase in the compression pressure. However, the amount of air required for cooling also increases and a point may be reached where the additional horsepower resulting from higher operating pressures will be consumed in moving the additional cooling air. Higher compression pressures also require higher starting torque. The starting torque must be kept low enough so that the user can easily crank the engine.

While considering the performance characteristics of an engine, the difference between a throttle controlled engine and a governor controlled engine should be noted. Most performance curves are shown for wide open throttle conditions. The nominal or rated horsepower of two-cycle engine is usually determined at speeds from 3,600 rpm to over 5,000 rpm, with the majority at 4,000 rpm. The speed selected is that which produces maximum horsepower with open throttle. Governor controlled engines are operated at speeds below the rated power speed, and therefore will deliver less than rated horsepower. The engine represented by curve *B*, Fig. 11, is rated at 3.6 hp at 4,000 rpm. However, if this engine is governor controlled at a speed of 3,000 rpm, maximum power output is only 3.0 hp or 0.6 hp less than rated. In addition, the governed speed of 3,000 rpm is assumed to be the no-load speed. Since the speed regulation of small engines with commercial governors is rarely better than 8 percent between no load and full load, there is an additional drop in speed of 240 rpm bringing the full-load governed speed to 2,760 rpm. At this point on the curve there is available only 2.7 hp. Thus if an engine which is rated and delivers 3.6 hp at 4,000 rpm is governor operated at 3,000 rpm the most horsepower that can be obtained is 2.7 or 75 percent of the rated power.

New Developments

Future small single cylinder engines are expected to develop one horsepower per cubic inch of engine volume with a weight of only five pounds per cubic inch.

Although present two-cycle engines are confined to one or two cylinder units, with improved machining techniques and materials, four, six or eight cylinder engines will undoubtedly be produced. These engines can be in-line, opposed or Vee.

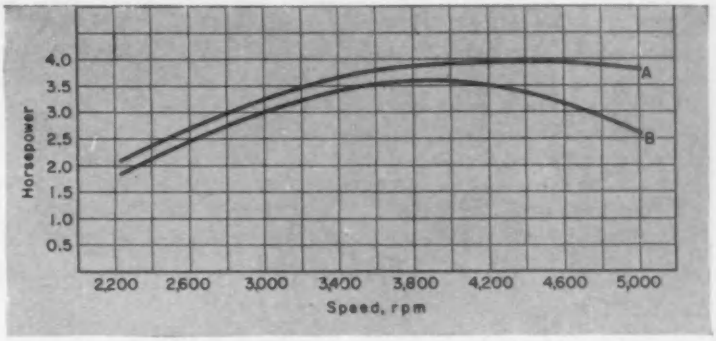


Fig. 11—Typical horsepower curves for two-cycle engine. Curve *A* is for engine without air filter and muffler while *B* is for the same engine with these accessories.

The ignition timing of the engine is dependent on engine speed; for relatively low speed engines the timing is retarded and for high speed engines the timing is advanced.

The selection of the proper carburetor venturi size will also depend upon the operating speed of the engine.

3. THROTTLE OR GOVERNOR CONTROL. The type of control is also related to operating speed and engine size. A governor reduces the horsepower output of an engine unless that engine is operated at rated speed. Also, the selection of the carburetor is often dependent upon the type of speed control. Some carburetors that will function satisfactorily with throttle control will not perform as well with a governor. Governors generally cause more wear on the carburetor throttle shaft and sometimes it is necessary to chrome plate this part for satisfactory operating life.

4. TYPE OF LOAD. Engines operating under light loads do not require much cooling air, and are frequently operated without the use of shrouding or ducting around the fan.

Heavy duty loads make necessary complete cooling shrouding, and many require the use of special cooling fans.

Spark plug selection is also dependent upon load conditions. Hotter plugs are generally used under conditions of light load. The selection of engine bearings is also dependent upon load conditions.

5. Stationary or Portable Application. This factor governs the selection of the carburetor, air filter and gas tank. A carburetor with a side float bowl will operate in a stationary position, but can be unsatisfactory on a portable unit. If the unit is to operate in any position, as is required by some chain saw manufacturers, it is necessary to use a diaphragm type carburetor. Some modified float bowl carburetors can be made to operate at angles up to 45 deg from normal.

The selection of the air filter is dependent upon whether the engine is stationary or portable. Stationary engines can be operated with either an oil bath or dry mesh type air filter. Portable engines that are subject to tilting cannot be equipped with an oil bath filter because of the danger of the oil running out.

In a stationary engine the location of the filler cap and the gas line outlet is a matter of convenience. In portable engines, it must be constructed so that fuel will flow to the carburetor at all angles and regardless of how much fuel is in the tank. The filler cap must be located so that there is a minimum possibility of leakage.

6. Starting Conditions. Most engines are started under light or no-load conditions. Where engines must be started under load conditions, changes must be made in ignition timing and in the carburetor.

The ignition timing must be retarded as much as possible, consistent with satisfactory power output.

The carburetor venturi must be as small as possible, because of the low velocity of air past the jet resulting from slow speed cranking. Frequently the bleed holes in the choke shutter must be reduced for proper choking action.

7. Environmental Conditions. The condition under which the engine is to operate can materially affect the design of the engine. High temperature or high altitudes can cause as much as 33 percent loss of power in a gasoline engine. If either of these conditions exist an appropriately larger engine must be selected.

Two-cycle engines are being successfully started and operated at temperatures as low as minus 75 F. Because the oil is mixed with the gasoline the engines will turn over as freely at this temperature as at room temperatures. With only minor revisions to the choke shutter, standard two-cycle engines can be started at temperatures down to minus 45 F. At temperatures below that point the application of heat to the intake system or the crankcase is essential. In dusty surroundings larger air filters are required, with detachable pre-cleaners being used in some applications.

Material changes are required if the engine is to be operated on or near salt water.

8. Replacement. If the engine is to replace an existing four-cycle engine, it is necessary to have the same power at the same speed. While this is obvious, it may not be generally known that two-cycle engines are usually rated at a higher speed than four-cycle engines. Replacements should not be made on the basis of the rated horsepower, but rather on the horsepower as indicated on the performance curve. In some applications the driven unit may require engine speeds below which the two-cycle engine will operate, so that changes must be made in the belting or gear ratio.

If the engine is to replace an electric motor, care must be used in the selection of the proper engine rating. Many electric motors can and do operate at 50 percent over their rated power, and can develop 200 percent of their rated starting torque. If the electric motor has been operating or starting under overload conditions a gasoline engine that can produce the additional power must be selected.

The most common error made in the selection of an engine for a specific application is the use of an engine with insufficient power.

ELECTROLYTIC MOLYBDENUM

Molybdenum, the refractory metal with many high temperature applications, has been produced electrolytically for the first time at the National Bureau of Standards. Using a bath of fused salts, NBS scientists Drs. Seymour Senderoff and Abner Brenner have produced high purity molybdenum in deposits that vary from fine powders to thick coherent layers, depending on process variables.

At present, molybdenum is prepared chemically as a fine powder by reducing purified molybdic oxide with hydrogen. However, the process is expensive; even more important, it is difficult to control the particle size and quality of the powder. Parts have to be made by complicated power-metallurgy procedures.

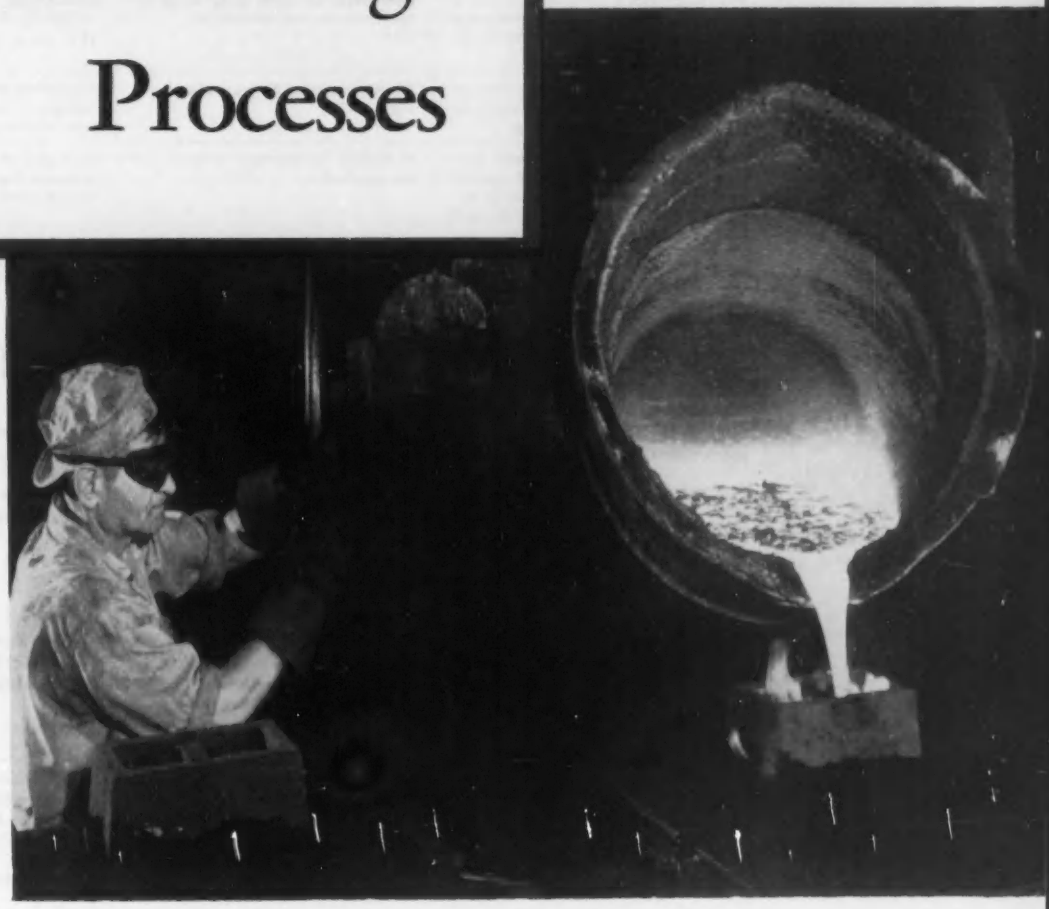
Electrolytic techniques would obviate many of these disadvantages. The NBS method, for instance, is relatively flexible and easy to control.

To designers, the big significance of this development is yet to come, stemming from improvements in the technique that would permit the electroforming of molybdenum objects. That would make possible the forming of complicated shapes like the combustion chamber of a jet engine or an afterburner.

Electroplating instead of powder-metal techniques would save many pounds of the metal, which is still critically short. And, at the same time, it would allow more designers to take advantage of the unique properties of the metal (Product Engineering, Jan. 1952, p. 121), by using molybdenum coatings instead of all-molybdenum parts.

One of the key steps in the process is the removal of all oxy compounds since their presence results in low current efficiency and impure deposits. So, all materials are dehydrated before use, and the process itself is carried out in a carefully regulated, inert, argon atmosphere.

Evaluation Of Casting Processes



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OF ALL THE METHODS of forming, casting is probably the most versatile. However, the selection of casting methods have been complicated by the advent of new processes such as shell molding; the revival of ancient processes such as lost-wax casting; and the advancements made in the fields of sand, plaster, permanent mold and die casting.

There is no definite procedure that can be used for evaluating a particular design to decide whether or not the part should be cast, and if so, in selecting the best casting process. However, certain criteria can be considered such as: size and weight; physical properties; dimensional tolerances; configuration; activity; and cost, which will, in turn, simplify the selection of the best process.

The six basic casting methods are sand, resin bonded shell, plaster, investment, permanent mold, die casting (see table on following page).

SAND CASTING. This is by far the most widely used casting process, and of the various methods it has the fewest limitations. It is not limited by size or type of alloy, and less by part design than any other process. (See *Product Engineering*, February, 1953.)

COMPARISON OF CASTING PROCESSES

Process	Sand Casting	Shell Molding	Plaster Casting
Cost	Hand methods—High labor and equipment cost, low tooling cost. Mechanization—Low labor cost, high tool and equipment cost. Production quantity determines method to be used. Extensive machining if part is unusable in as cast condition.	Low labor cost, medium tool and equipment cost. Process lends itself to a high degree of mechanization. Little machining necessary unless very close tolerances and finished are desired.	High labor cost, medium tooling and equipment cost. Part cost fairly high. Limited mechanization is possible. Little machining except if very close tolerances are desired.
Size and Weight	Wide range from a few oz. to 100 tons or greater. Wide use in medium and heavy range. Material used is usually determining factor.	Application in range of ½ to 20 lb. Special castings to 200 lbs.	Standard size about 12 x 18 x 4 in. Weight up to 15 lb. Special parts to 35 in. dia. and 200 lbs.
Complexity	Simple to very complex shapes that require extensive coring. Particularly reentrant angles or internal coring.	Simple to limited coring. Must have slight draft.	Permits the production of intricate design features to an accuracy that requires little or no machining.
Section	3/16 in. for small parts. Generally ¼ in. for small and medium parts. For highly stressed or pressure tight parts, ½ in.; for large parts ¾ in. Sections 4 ft. thick have been cast in steel	Relatively thin sections ⅛ in. or less are standard.	Thin sections possible to 0.040 in. if area is smaller than 2 sq. in. 0.052 in. for 4 to 6 sq. in. 0.093 for areas to 30 sq. in.
Surface Quality	Inferior to die or permanent mold castings. Surface roughness range 250 to 1,000 rms. Special facing sands can reduce valve below 250.	Superior to sand castings on ferrous castings. Excellent or non-ferrous.	Production roughness to 30 rms or better.
Mechanical Properties	Generally lower than other processes. Can be improved by metallurgical control.	Better than sand casting. Improvement attributed to metallurgical control.	Tensile properties low because of slow cooling and solidification.
Production	Low to High Production—Depending upon application.	Medium to high process. 1,000 to 100,000 units.	Low. Not a high production process. 150 to 450 pieces per pattern per week.
Dimensional Tolerances	Small to medium castings, ⅛ in. min. stock for finished surfaces. Large units, ¼ in. Generally depends on metal being cast.	Very good tolerance ±0.005 in./in. (Not applicable in parting plane.) ±0.010 across part plane.	±0.005 in./in. for production casting. ±0.010 in./in. across parting line.
Applications	Gears, framing members, housings, motor blocks and structural members when cast structures having relatively low strength and resistance to impact are satisfactory. Usually limited to cast iron and cast steel for industrial equipment.	Valves, crankshafts, parts made by rough machining and forging. Possible applications in heat resistant and special alloys such as titanium alloys.	Torque converters, complicated copper base parts, machine parts. Can cast around inserts.
Materials	Steel, cast iron, copper base alloys, aluminum alloy and magnesium alloys	Best for high alloy steels, cast iron, copper and aluminum alloys. Carbon steel, magnesium and special alloys can be cast.	Any nonferrous alloy with a melting point of less than 2,000 F except magnesium in large sizes. Includes aluminum, brass, bronze, beryllium, copper.

From the same alloy, however, the properties of sand castings will not, in general, be as consistent as in other processes. Sand casting is essentially the only method for producing castings from 100 lb up to several tons, and for producing castings that have complicated internal shapes.

The tolerances and finishes achieved by conventional sand casting are the poorest of any of the processes, but when accuracy and finish are not prime requisites it is often the cheapest method of obtaining a casting. Sand casting techniques are often used to produce sample models or short runs as inexpensive wood patterns can be used that can be easily modified.

Specialized foundries, using tight process control and special facing sands and cores, have produced premium or engineered sand castings. Castings produced by this technique carry premium prices, but surface dimensional control and detail are good.

SHELL MOLD (Resin Bond). Basically shell molding takes advantage of thermosetting resins to bond washed silica sand into a permeable shell about ¼ in. thick. This shell may be backed up with such material as steel shot or crushed granite prior to use as a mold for casting both ferrous and nonferrous metals. The resultant casting is of a precision nature in both tolerance and finish. The tool for shell molding is a match-plate type and must be machined from a metal that will withstand cyclic heating to about 600 F. Both aluminum and steel pattern plates are being used, the best results having been achieved with steel. The cost of tooling for shell mold is, in general, higher than for a match plate sand pattern.

Shell molding lends itself to a high degree of mechanization, and where

Permanent Mold	Die Casting	Precision Investment Casting
High labor, tooling and equipment costs. Fairly high part cost. Little machining necessary except for very close tolerances.	Low labor cost, high tooling and equipment costs. Low part cost on high quantity items. Machining usually not necessary.	High labor cost, low tooling and equipment costs. High part cost. Little machining necessary.
A few oz. to 500 lbs. Usually medium and large parts. Used between sand and die casting	No real size limitation. Size depends upon casting equipment available. Present maximum weights are: 15 lb. aluminum, 10 lb. magnesium and 30 lb. zinc.	Size range up to 16 in. Weight range to 35 lbs. Most parts from 1 oz. to 3 lbs.
Simple parts with limited coring.	From simple to very complex.	Intricate shapes not readily made by machining, forging or sand casting can be produced.
Sections to ⅛ in. Grey iron min. section about 3/16 in.	0.040 in. to a max. of 1½ in. if some voids are permissible. Usually ½ in. maximum.	Tolerance in walls no less than 0.005 in. min. Max. section about 1.0 in.
Surface dependent upon the condition of the mold. Can be machined or ground but usually left with base metal surface.	Excellent, 40 to 100 rms. Can be finished with a variety of mechanical, plated, chemical or organic finishes.	50 to 80 rms normal finish.
Strength about 10 to 20 percent over sand castings.	High surface strength, poor if machined.	About equal to mean between transverse and longitudinal values for rolled bars of the same metal and alloy.
Relatively low. Lies between sand and die casting.	Very high. Up to 500 shots/hr. possible with some parts.	In normal alloys low to medium. In special alloys low to high.
Fixed cavity tolerances run ±0.020 in. and ±0.030 in. across parting line. Solid die tolerances run ±0.010 in. for 1 in.	0.0015 in./in. for magnesium and aluminum. 0.001 in./in. for zinc. 0.003 in./in. for copper base. Above for any one dimension. Dimensions across die parting line are normally about double above figures.	Min. general tolerances are ±0.005 in./in. ±0.003 for each additional inch for ferrous. Lowest production cost where tolerance is set at ±0.010 in./in.
For parts similar to sand castings but which may have superior surface finish, closer tolerances and better strength in as cast condition.	Structural parts, machining elements, and decorative members and parts for automotive, business machine, electrical appliances, and all other high production industries.	Small intricate shapes made in limited quantities usually from high alloy metals such as stainless steel, Inconel, Hastalloy.
Best for zinc, aluminum, copper-base alloys. Cast iron for some applications. Not suitable for steel.	Lead, tin, zinc, magnesium, aluminum and copper alloys.	Iron, zinc, magnesium, aluminum, copper base alloys, and especially high alloy steels.

high production exists the cost is comparable to sand casting for a vastly superior product.

At the present stage of development, most applications of the process are on castings weighing ½ to 25 lb. Applications have been made in excess of 100 lb, but these are limited at present by technology of the process.

By far the most valuable asset of shell molding is the dimensional accuracy and finish that can be obtained. Large savings can be realized by eliminating subsequent machining operations on castings.

The shell molding process is claimed to be the greatest stimulus that has hit the foundry in many years. It fills the gap, with considerable overlap, between conventional sand molding and investment casting. (See *Product Engineering, October 1952* and *September, 1953*).

Extensive research is now going on to arrive at a better understanding of the principles of metal solidification; the evaluation of new sands; the use of new materials for patterns; and the design of new process equipment. (See *Annual Handbook of Product Design, 1954*).

Shell molding has opened the casting field to many new applications. A large percentage of the parts now being produced were designs previously produced by the machining of forgings or wrought material.

PLASTER CASTING. A form of precision casting that uses the cope and drag method similar to sand casting has only recently been widely applied. Since a slurry of plaster, depending on gypsum or calcium sulphate for bond is used as mold material, the process is limited to those metals that melt below 2,000 F such as brass, bronze, aluminum and magnesium.

However, many of the aluminum and magnesium castings that can be made by this process are readily produced by the more economical die casting method. For this reason plaster molding has been limited to relatively short runs of castings which cannot be economically produced by die casting.

Plaster casting has an outstanding advantage in that complicated coring can be made and intricate parts with back draft or re-entrant section may be cast. The slurry will follow the contour of the pattern, resulting in close tolerance and an excellent definition. Similarly, surface finish of plaster castings is superior to that achieved in sand casting.

Because of the poor conductivity of the plaster, mold solidification is slow and the physical properties, in general, are inferior. The metal will generally have coarser grains and slightly lower tensile properties than are obtained with metal molds or sand castings. The permeability of the mold material can be adjusted to accelerate solidification, but the properties will remain low.

The use of plaster casting is normally restricted to castings weighing two to three pounds, although recent methods in application of this process to torque converter parts have increased this weight range.

PERMANENT-MOLD CASTING. This process produces a casting in a mold that may be considered to be permanent in nature. The mold cavity may be machined from a metal such as cast iron or tool steel, but ceramic or refractory molds and cores can be used if special cooling conditions are desired.

Permanent-mold castings are common in the size range of a few ounces to 200 lb, although parts have been made by this process up to 500 lb.

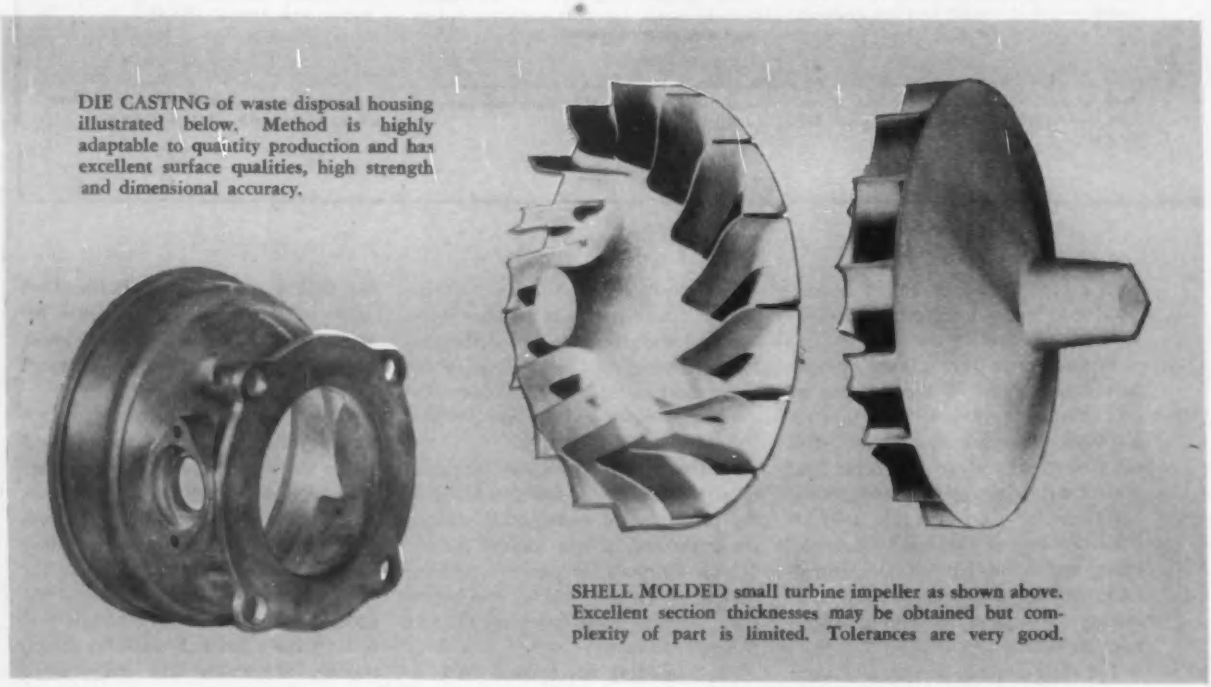
This process produces castings that are characterized by metallurgical superiority, pressure tightness and good surface finish. These advantages can be attributed to the chill of the metal caused by the metal molds and the good feeding of the molten metal obtained by the process.

Most non-ferrous alloys can be cast successfully by this process. It was not considered suitable for steel until the development of modern techniques for centrifugal casting. Now, alloy steels such as types 410, 342, and 316 are permanent mold cast. These steels are widely used for jet engine parts and other precision components subjected to high temperature and corrosive conditions. (See *Product Engineering, November 1950*).

Aside from jet engine applications the process is readily adaptable to the production of a variety of bushings, valve seats, pump liners and other cylindrical and circular shapes in a wide range of alloys. It offers particularly significant possibilities for the production of circular shapes required by the oil, chemical, textile, paper and pulp industries.

Experience in the production of these components has shown the process to be relatively inexpensive, and a reliable method for producing parts in special steel which, by virtue of their special properties, are difficult to fabricate by other methods.

DIE CASTING. This process differs mainly from permanent-mold casting in that the metal is introduced into the mold under pressure. The process is normally confined to relatively small parts, however advanced techniques are permitting the casting of larger parts and complex parts. For instance, a magnesium alloy dictating machine housing measuring 8½ by 12 by 6 in. with an average wall thickness of about ⅛ in.; or an aluminum alloy deicer valve incorporating sections that range in thickness from $\frac{1}{16}$ to ½ in., have been die cast. Because of the size and cost of the mold or die and the machining required, quantity of castings must be relatively high to make production economical.



DIE CASTING of waste disposal housing illustrated below. Method is highly adaptable to quantity production and has excellent surface qualities, high strength and dimensional accuracy.

SHELL MOLDED small turbine impeller as shown above. Excellent section thicknesses may be obtained but complexity of part is limited. Tolerances are very good.

Coring in the die-casting process is limited to parts where cores can be withdrawn. The process is also limited by section size, most die castings being of thin section so that they will solidify quickly. Major advances are being made along these lines and heavier cross sections are being made.

The advantages of the die casting process include rapid production, good finish, close tolerances and minimum machining. The outstanding advantage is the high production rate possible, which results in a very low cost providing the production is sufficient to offset the high tooling cost. In general, die casting as a production process is limited to zinc, aluminum, copper and magnesium-base alloys.

With the development of larger, high-pressure die casting machines, metallurgical controls and special die materials, larger, more complex parts can be produced. An indication of this trend is the serious thought being given to the die casting of higher melting point alloys.

INVESTMENT CASTING. The impetus of war, coupled with the need for a casting technique capable of producing fine surfaces and dimensional accuracy on intricate shapes from special alloys, stimulated the revival of the art of lost-wax, or "precision investment", castings. Investment casting uses expendable patterns that are completely invested with a silicone mold material. The pattern is melted or burned out of the mold, leaving a cavity that is an accurate reproduction of the pattern. After a firing cycle, which completely eliminates the pattern material and all moisture from the mold, metal is poured under pressure into the cavity.

There are several innovations of this basic process. Pattern materials of organic waxes, plastics such as polystyrene, and frozen mercury are used. The use of plastic patterns is normally limited to high production parts for which steel dies can be machined. Soft metal injection dies are used to form expendable wax patterns.

Essentially all castable alloys can be used. This includes light metals, copper base alloys, low carbon steels, tool steels, stainless steels and high temperature alloys. Alloy selection and design procedure when properly followed will produce a sound investment casting. (See *Product Engineering, November 1951*).

The size and weight range of castings has grown in the last few years. Investment castings were limited in weight to about 10 lb maximum, but recent castings have weighed up to 35 lb. This advance in size and density is obtained by temperature and pressure control. (See *Annual Handbook of Product Design, 1954*).

General Consideration

There is no definite procedure that can be outlined for evaluating a particular design to decide whether or not the part should be cast. However, there are certain criteria that should be considered such as configuration, size and weight, properties, dimensional tolerances, quantity and cost.

Configuration. This is usually the first to be considered and determines whether or not the part need be a casting. A part that can be made from stock wrought material without excessive material removal or number of operations is normally more economical to machine. If excessive machining is involved or when the material required is difficult to machine or form, a casting may be considered.

Size and Weight. These factors are also an early consideration. If the part weighs less than 10 lb, any of the casting processes may be considered; if over this weight, the choice of method may be restricted. However, the constant advancements being made in casting processes are reducing the importance of size and weight in considering a method.

Physical Properties. A common pitfall is the acceptance of general published properties of an alloy and to disregard the state or the condition of the test specimen used to determine the properties. Before proceeding beyond the initial stages of design a reliable source should be consulted to determine properties of a particular alloy when cast by a particular process.

If a ferrous part is necessary, the processes are limited to sand casting, shell molding or investment casting; for a non-ferrous part any of the processes can be used.

Dimensional Tolerances. All of the processes have definite dimensional limitations that must be carefully considered when selecting a process and

PLASTER CAST circuit breaker parts. Note re-entrant angles and good surface detail. Little or no machining is needed prior to part assembly.

estimating final cost. If hard to machine tolerances can be held by one of the precision casting methods, the saving in machining may offset the use of the more expensive method. If certain dimensions must be held to a close tolerance it may be easier to design them with a healthy stock allowance for subsequent machining. If $\pm\frac{1}{64}$ in. will do just as well as ± 0.003 in., then the wider tolerance should be used.

There have been fabulous claims concerning the tolerances being held on shell molded and investment cast parts. These may be true in part, applying only to one or two dimensions on the casting. A rule applied to general tolerances on these and plaster castings are ± 0.005 in. for one in. or under and ± 0.003 in. for each additional inch. Parts produced by "precision casting" processes are precision only when compared with parts produced by other less precise casting processes.

Of all the methods, die casting is probably the best as far as dimensional requirements are concerned. In plaster and shell mold casting, the dimensions across the parting plane should carry a wider tolerance range than other dimensions.

Quantity. The production quantity of a casting may dictate not only the process but also the pattern or die. In this respect sand casting offers the widest range of application. A wooden pattern is often used to produce one to several thousand castings. However, for a high quality or quantity, sand castings are normally produced from matched metal dies.

Shell molding is a highly mechanized process, thus making it ideal for high production runs. Tooling costs are also high as metal patterns are needed for even low production making the initial investment higher than for sand castings.

The high cost of machining metal dies usually restricts the use of die casting to those parts produced by the thousands. Plaster and permanent mold castings fall in an intermediate range between sand and die casting, but as the cost of tooling is higher than for sand, these methods are expensive for low production runs.

Investment casting tool costs are lower than for plaster or permanent mold but still higher than sand. It is possible to cast from a machined counterpart a soft metal die which will permit the investment casting of a few units. If several thousand parts are required a hard steel die is machined. The range of application can vary from a few parts to several hundred thousand.

Cost. After considering the above factors, the applicable methods are normally narrowed to two or three. The final choice will be dictated by the most economical method of producing the parts in the desired quantities.

This determination should be made only after a complete analysis of those factors contributing to the final cost of the finished part has been made. Not only should the cost of rough casting be considered but also the cost of pattern or dies, the fixtures and jigs and the machining operations necessary to ready a completed assembly. The initial cost of a rough sand casting will be lower than the shell molded or investment cast counterpart, but if numerous machining operations are necessary prior to assembly, the final cost may exceed that of the more expensive processes.

As a general proposition, the following formula may be used:

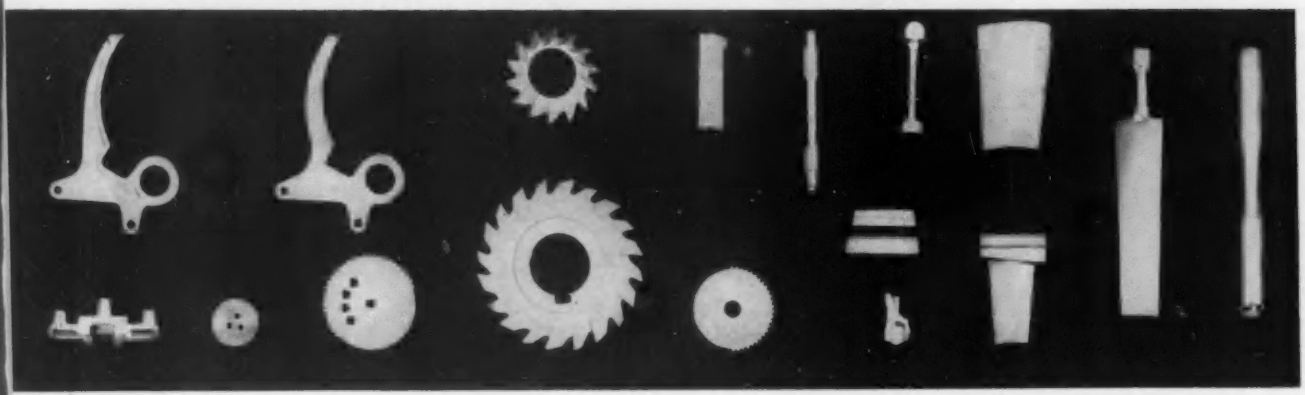
$$\text{Unit cost} = \frac{T + N(P + F + M + A)}{N}$$

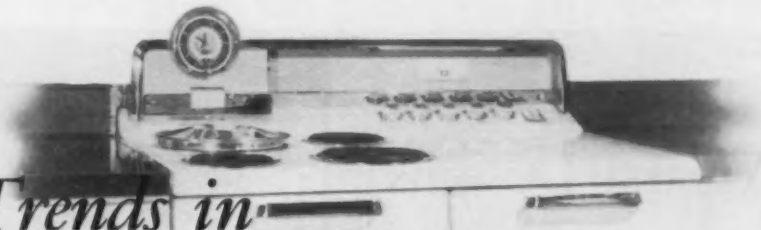
where T is the total tool cost, P the price per piece quoted by the manufacturer, M the customer's cost of machining the piece, F the customer's cost of finishing the piece, A the customer's cost of fitting the part into a composite assembly, and N the number of parts making up the whole lot.

The piece price P, of course, must be based on a definite schedule of production in order to take care of intermittent setup charges. Some consideration must also be given to the question of whether the original quotation includes a "one-time" charge for tools with no further obligation to the customer as in die castings, or whether upkeep, repairs, and renewals of tools will have to be paid for periodically.

The purchaser should therefore not be prejudiced against a certain process if one of these factors seems to be much higher than it is for another process as long as some of the other factors make up for it. For instance, in die castings the tool cost may be very large, but if the saving in labor cost and cost of machining is considerable and the number of parts ordered is high enough, the final answer to the equation is generally favorable. Obviously, on the other hand, if N is low, M particularly must be quite large to get a favorable end result from the formula for the parts produced.

VARIETY OF PARTS cast by precision investment molding. Intricate shapes can be made with good strength characteristics and surface quality. Dimensional accuracy is good. Tooling costs are relatively high.





New Trends in—
APPLIANCE DESIGN

TO KEEP PACE with the change in the country's living habits, earmarked by the growing concept of casual living, appliance manufacturers have been quick to put their major design effort behind styling and operating convenience features. Underlying their approach is this theme: If the mechanism functions as desired, don't change it until absolutely necessary. As a result, major household appliances bear a striking mechanical similarity to predecessor models, but differ considerably stylewise.

REDESIGNING FOR MAINTENANCE is one area being actively exploited by most manufacturers. In the past, appliance dealers have been criticized for poor servicing. Part of the criticism is justified. But a good portion can be blamed directly on the manufacturers —mechanisms are often so intricate that appliances require constant adjustment. Also, many independent service shops are technically incapable of repairing the units. Many manufacturers soon found themselves in constant "hot water". Even dealers began pushing those lines they knew would give the least trouble.

But all the blame cannot be laid entirely to the design itself. A performance standard has been unconsciously set for the appliance industry —the refrigerator. The American public has been accustomed to years of trouble-free operation from its refrigerators; it does not expect less from other appliances. Manufacturers thus find themselves facing a paradox: Appliances are becoming more complex in their operation to meet consumers' demands, but the same dependability of performance is required as before.

To [illegible] this situation, manufacturers are redesigning their equipment and operating mechanisms for simplicity and ease of maintenance. A "performance reserve" is being built into new units to allow for extreme conditions. And additional controls are being added to take more of the operation out of the user's hands to insure a predicted reliability.

MARKET SATURATION plays another important role in appliance design. Ranging from refrigerators down to water softeners and air conditioners, relative degree of market saturation influences the design approach used. With highly saturated lines, manufacturers must continually keep adding new features or improvements that make the public less desirous to keep older models. In those lines growing in market acceptance, features that work and sell are kept as long as possible. Changes are primarily made because of competition, one manufacturer staying in step with another, or natural design evolution based on new materials and improved production techniques.

Another aspect is the move by several large manufacturers to squeeze out a little more "cushion" in the production of their highly competitive models. With an eye to more efficient distribution methods, new, single product plants are being built to enable the latest in production techniques to be applied. What is happening is an effort to reduce manufacturing costs by improved production methods. This, in turn, is allowing newer features to be added without increasing cost.

[illegible]IONAL DESIGN of appliances is stressing the growing concept of casual living. Color, size and exterior design point up definite trends in consumers' thinking. Concealed appliances, flush-fitting units and use of modernistic styling are some examples. Appliances that blend in with the decor of the home without detracting from working space is another. Slowest moving will be use of color. While color is appearing more and more on control knobs and instrument panels for eye-appeal and to indicate a particular phase of the function being controlled, widespread application to exteriors is still far off. Principal reasons: difficult-to-evaluate preferences for certain colors and passing color fads. This adds up to a costly inventory problem—what color to use, how many such models to manufacture and when. Traditional white for the kitchen and laundry and easy-to-blend-with gray and brown for living areas present no such problem.

CONTROLS have been receiving more attention from appliance designers. Newer models show application of controls that allow more automatic operation. One control is taking the place of two others. And emphasis is on "operator-proof" design. More sensitive indicating and regulating devices are being installed to permit closer control over the operation, reducing the amount and degree of supervision formerly required. Electronic units are starting to appear, being added to incorporate control features impossible to obtain with conventional equipment. But as more controls are added, increasing design emphasis is on dependability and maintenance ease.

Amana Designs Freezers for Volume Production

AMANA'S NEW 19 cu ft upright freezer is capable of storing over 685 lb of frozen food—almost 90 lb in module-type door. Heart of door storage is package stacking arrangement which is based on a depth dimension of 4 in., common to all food packages. Movable holders form vertical chutes, easily adjusted for different package widths.

In the past, upright food freezers have been designed for low production with an eye to economy in tool expenditure, or have been adapted from household refrigerator cabinets with some compromise of design objectives. Conceding that the upright freezer required a distinctly different design, manufacturers have been—as a general group—loathe to put too much money or effort behind design until sales reached a "safe volume level".

Now, in one of the first significant moves by the home freezer industry to shake-off the traditional refrigerator approach to freezer design and production, Amana Refrigerator Co.; Amana, Iowa has come up with a new line of upright models, featuring 40 percent less parts than last year's models plus several items promising to set new industry trends. Most striking design change is in the outer case assembly where the number of parts has been reduced from 34 to 11. Another significant change is designing the compartment liner to be inserted from the front rather than the rear. This makes it possible to permanently weld in the back in one operation thereby eliminating over 100 machine screws formerly used.

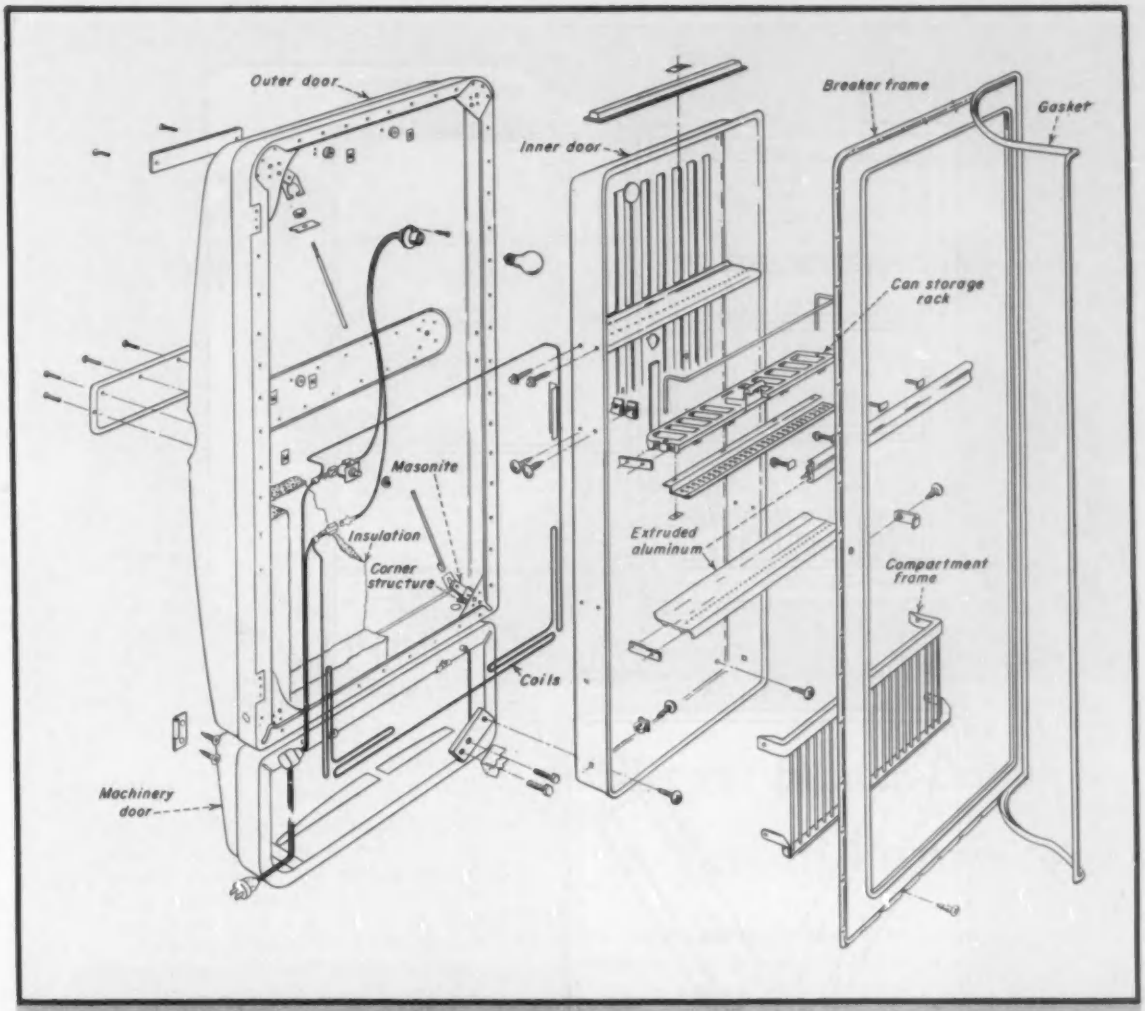
Underlying the design approach was the arrangement of space to place the maximum number of frozen food packages in immediate sight. To meet this requirement, a module arrangement was developed which permitted easy vertical adjustment of inner door space to insure full door storage regardless of package widths.

Designing the door around the food load resulted in an entirely new door design, one that is capable of storing over four times that of predecessor models. Constructed of three sections, new door holds almost 90 lbs of frozen food—about 12 percent of total freezer capacity.

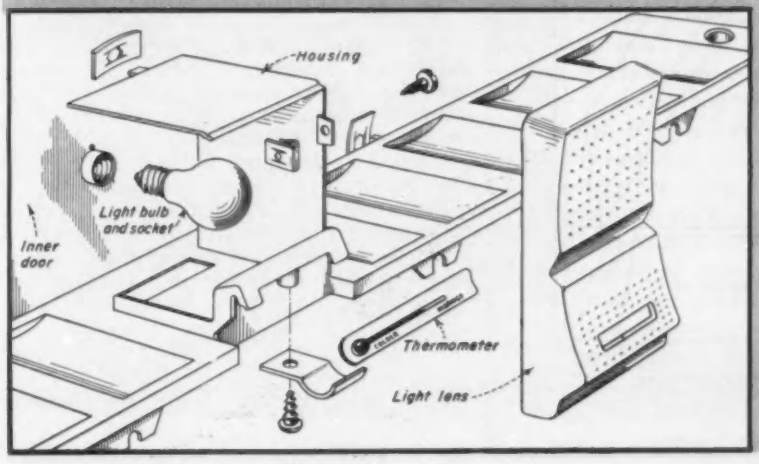
Combined door and freezer load necessitated new approach to reinforcing cabinet to insure proper alignment of door gasket on case and latch mechanisms with the strike. Based on characteristic of open box to resist deformation along its open side when any of the closed sides are reinforced, back of outer case is embossed with an "X". A small plate welded at the center of embassment then forms a structure similar to an automobile X-member chassis.

To easily swing heavy door and minimize noise, hinges with nylon bearings were adapted. Inner door lighting is unique in that it was developed especially for a freezer—having nothing in common with refrigerator lighting schemes.

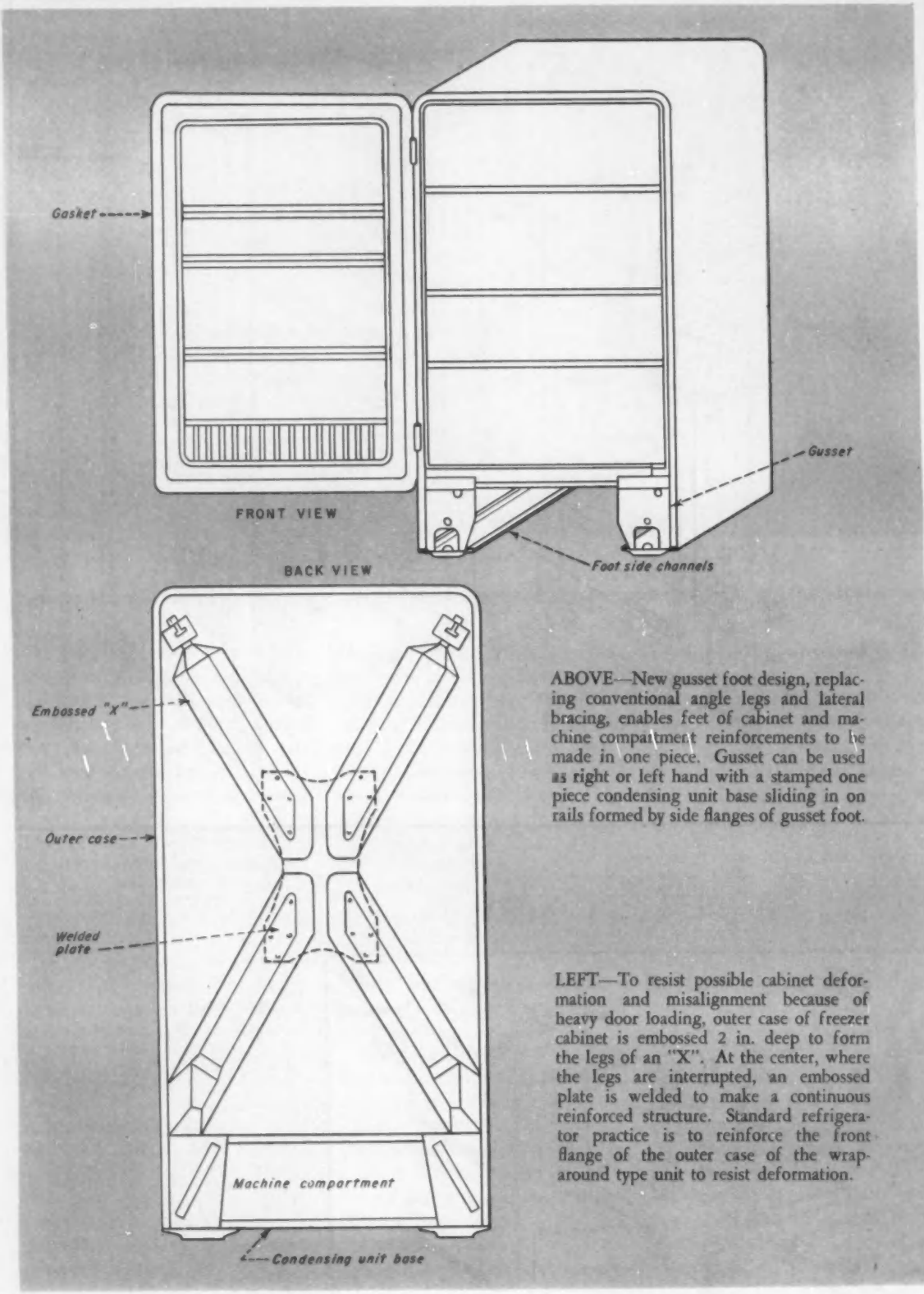
Other design changes include combining cabinet feet and all brackets and reinforcements used in compressor compartment into interchangable right and left hand parts. Also, extensive use has been made of aluminum extrusions as both decorative and structural members.



FREEZER DOOR consists of three sections: Inner and outer doors spaced apart by masonite blocks which also serve as thermal barriers, and a one piece polystyrene breaker frame. Four corner structures make outer door into a rigid section. Both door sections are drawn steel pans, outer door being 58 in. high, 36 in. wide, and 8 in. deep to accommodate 3½ in. of fiberglass and 4 in. food packages.

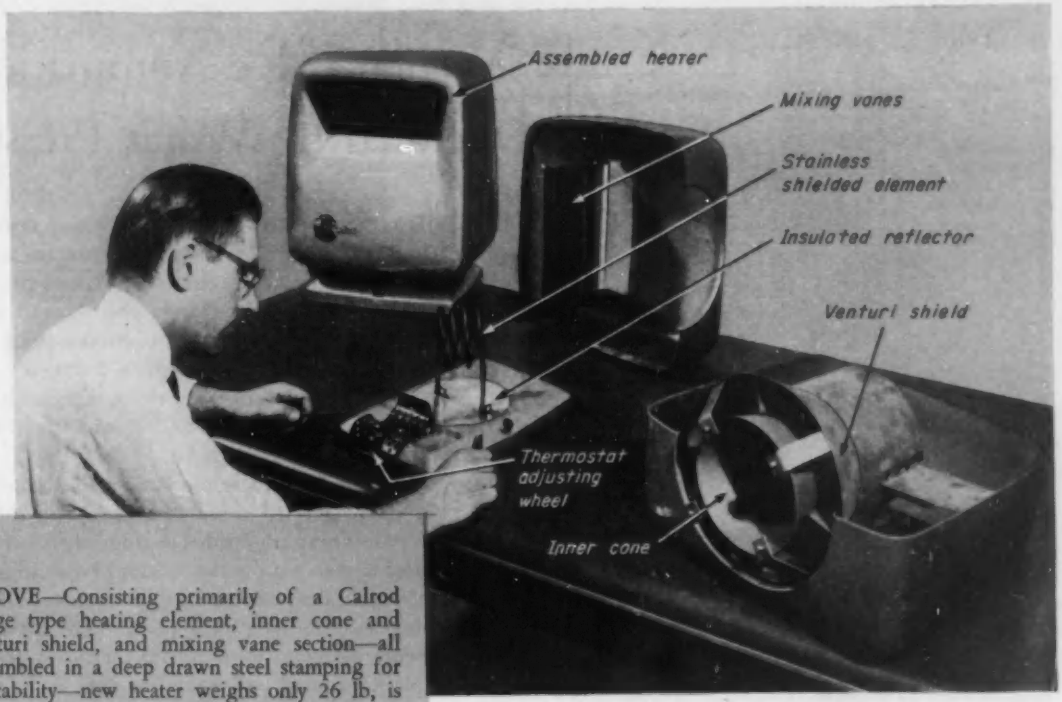


NEW LIGHTING arrangement designed to illuminate contents of door and main food compartment has ordinary light bulb furnishing light through plastic lens. Located at center of inner door section, concave lens bends light to reach most of freezer storage area. New position for light source was required since large door storage and compact shelf arrangement precluded use of conventional refrigerator lighting design.



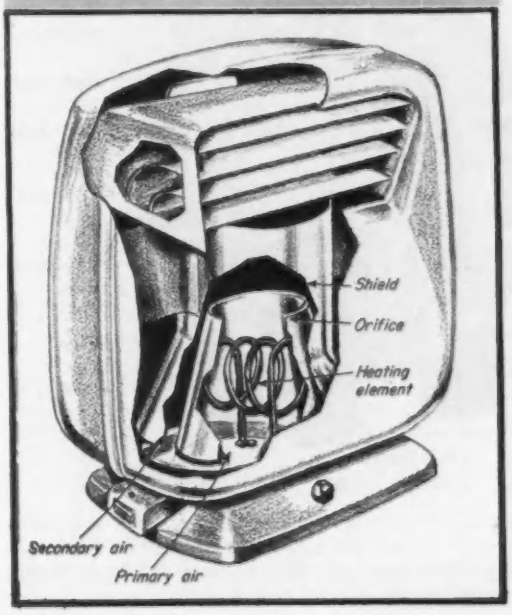
ABOVE—New gusset foot design, replacing conventional angle legs and lateral bracing, enables feet of cabinet and machine compartment reinforcements to be made in one piece. Gusset can be used as right or left hand with a stamped one piece condensing unit base sliding in on rails formed by side flanges of gusset foot.

LEFT—To resist possible cabinet deformation and misalignment because of heavy door loading, outer case of freezer cabinet is embossed 2 in. deep to form the legs of an "X". At the center, where the legs are interrupted, an embossed plate is welded to make a continuous reinforced structure. Standard refrigerator practice is to reinforce the front flange of the outer case of the wrap-around type unit to resist deformation.



ABOVE—Consisting primarily of a Calrod range type heating element, inner cone and venturi shield, and mixing vane section—all assembled in a deep drawn steel stamping for portability—new heater weighs only 26 lb, is 21 in. high, 17 in. long and 11 in. wide.

BELOW—Air is drawn inside the inner cone and over the heating element, discharging through top orifice and pulling additional air into the heater. Secondary air is drawn between venturi shield and inner cone. Entire mass is then further mixed and directed into the room by vanes to create an even flow.

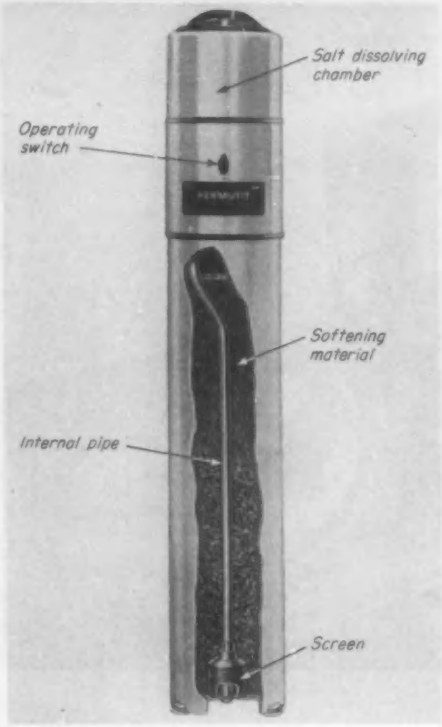


Electric Heater Borrows Jet-Venturi Principle

Based on the principle that when heated, air rises and expands, so that when directed through an orifice, increases in velocity, a new electric convection heater developed by Federal Products Div. of Federal Malleable Co., Milwaukee, Wis. has no moving parts and consists of only six major components.

Operation is predicated on the aviation jet-venturi system. Heat source is a range type element controlled by a standard thermostat. Two cones, one fitting over the other, and a series of curved fins complete the assembly. Approximately 60 percent of the circulated air is pulled into the inner cone and heated. The secondary air is drawn into the heater between the two cones by a vacuum created when heated air discharges through top end of inner cone. Air is mixed at top of heater and directed into room at velocities up to 135 ft per minute.

Rated 1,500 w, 120 v, the Vectaire is said to convert 94 percent of input energy into the airstream, only 6 percent radiating through the case. Because of low radiation loss, the case temperature never rises over 10 F above ambient. Other advantages claimed include such safety features as sealed heating element and ability to operate in any position. No moving parts to wear out and minimization of noise are additional features pointed out.



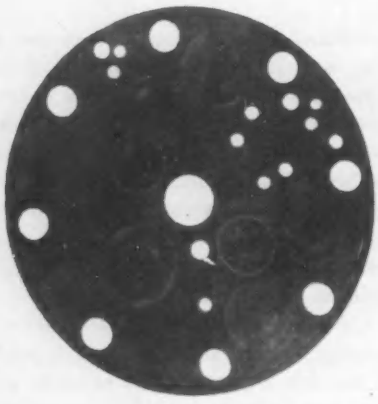
EMD water softener shown in cutaway operates with equal efficiency at flow rates from 0 to 6 gpm. Approximately 55 in. high and 9 in. in diameter, the unit contains 0.9 cu ft of ion exchange resin which is sufficient to remove 25,000 grains of hardness from raw water. The softener is automatic from backwash through regeneration and back to softening. A timer is used to change from softening to backwash.

Softener Valve Automatically Operated by Water Pressure

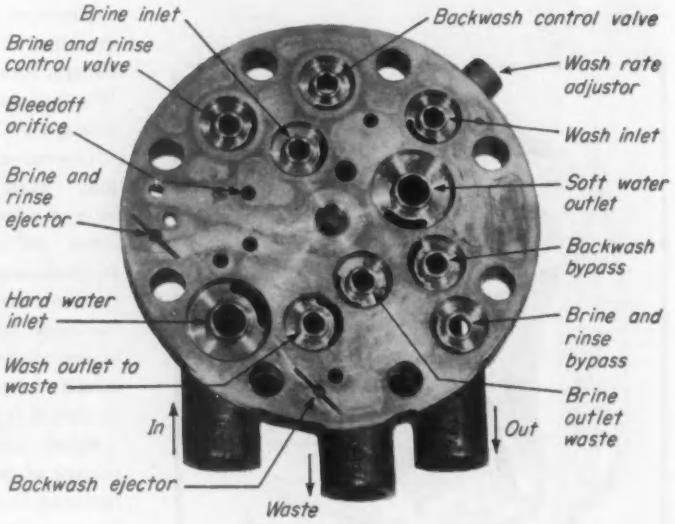
The EMD water softener, developed for home use by The Permutit Co., New York, N. Y., uses water pressure acting on a rubber diaphragm to open or close valve ports for softening, backwash and regeneration. Sandwiched between two internally cored plates, the diaphragm controls a total of ten valves to select the cycling operation desired. Primary control of the water pressure which operates the diaphragm is by energizing the proper solenoid valve to admit or cut-off flow to the valve assembly.

Water pressure is directed to the various diaphragm ports through the interconnected cored passageways in the valve plates. Some ports are spring-loaded to close when water pressure is admitted to their top cavities. Others have springs placed in deeper recesses in the plates to exert less pressure, allowing faster opening and closing of the ports. Since springs and poppets are only needed to aid in seating the valves, port closing is a simple function of redirecting the flow.

From one cycle to another, port opening is accomplished by relieving the pressure on the top side of the diaphragm. Ejectors, the flow through which is controlled by the solenoid valves, create a Venturi effect over certain valve ports permitting water pressure to lift the diaphragm valve off its seat. This allows a new circuit to be set-up for the cycling action.



DIAPHRAGM



VALVE PLATE

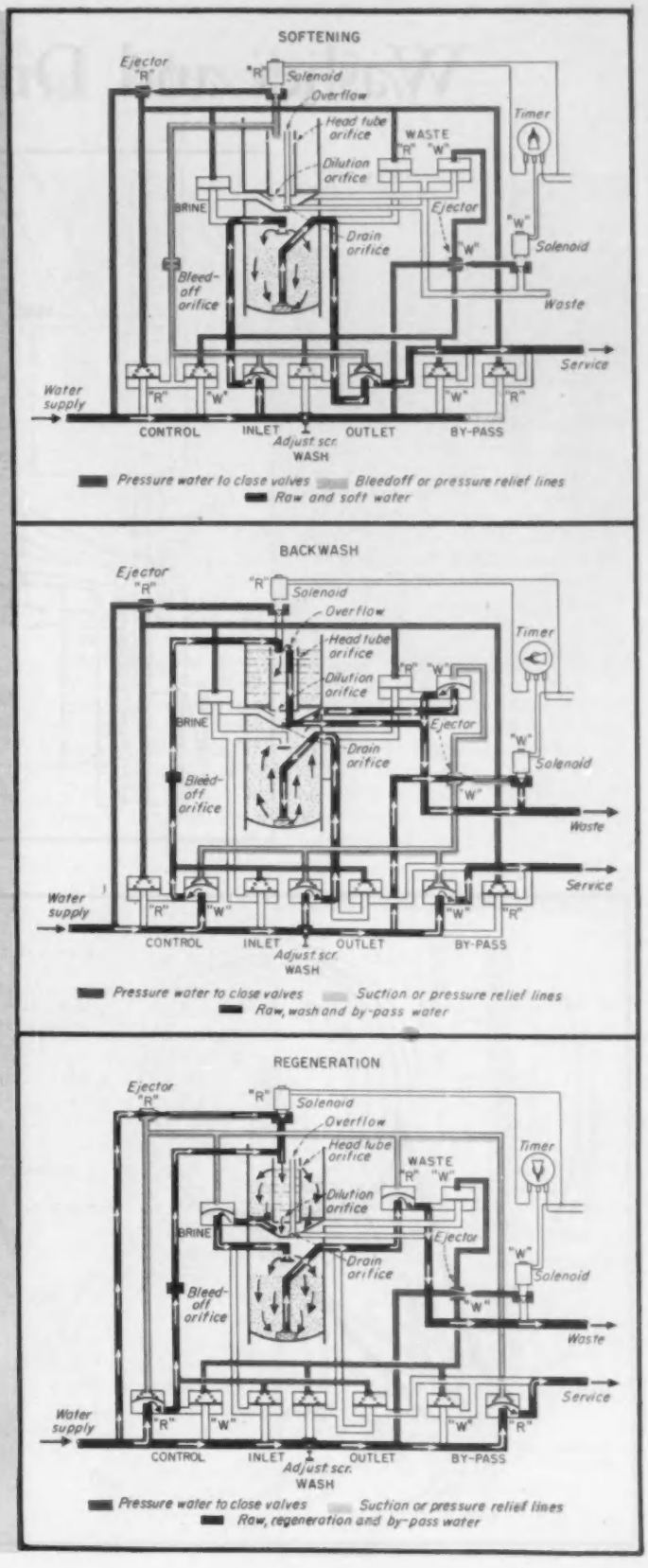
HEART of the softener is the rubber diaphragm and valve plate assembly. By function, the valve ports can be divided into three groups: (1) inlet and outlet valves; (2) backwash control and by-pass valves, wash inlet and outlet valves; and (3) brine and rinse control, inlet and outlet valves, and by-pass valve. Because of positive diaphragm valving action, tolerances are not critical in the machining or assembly of the valve plate and cover.

Operation of the Diaphragm Valve Assembly

SOFTENING—As raw water flows into the unit, water pressure is channeled to close all valves except wash inlet and outlet. All of the flow passes through the inlet valve and out of the valve assembly onto the bed of zeolite. After passing down through the resin, the softened water is forced up through the internal feed pipe back into the valve assembly and out of the outlet valve to the house service.

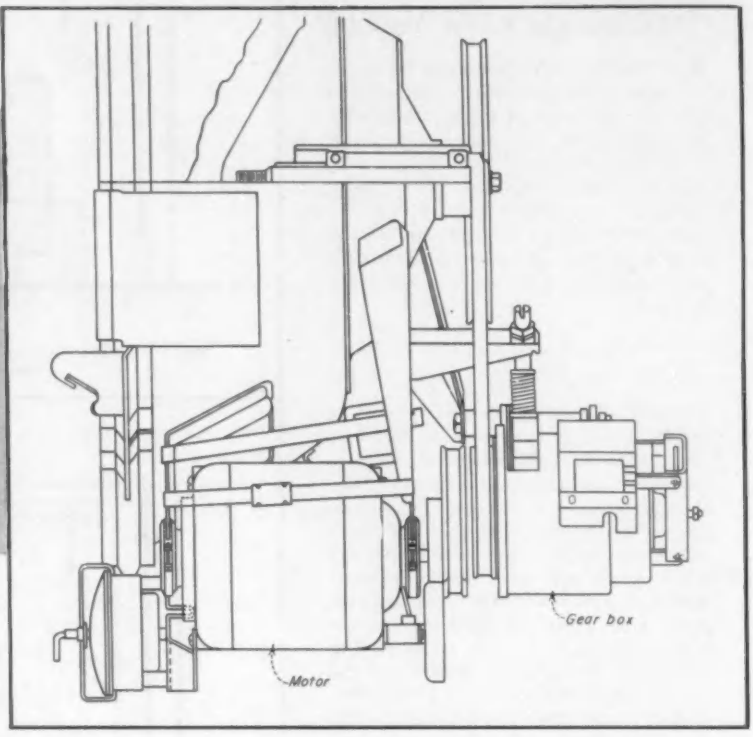
BACKWASH—Turning the operating switch to regeneration starts the backwash cycle. The backwash solenoid valve is energized allowing raw water to flow through its injector creating a suction on the backwash control, by-pass and waste valves, and on the wash valve. Inlet and outlet valves are now closed by water pressure. Raw water flow is through the wash valve down the feed pipe to the bottom of the tank. The water is then forced up through the zeolite bed and out the backwash waste valve to drains. Part of the water is bled into the brine tank to prepare it for the regeneration cycle. Another part goes directly to the service lines to insure a supply of water for household use.

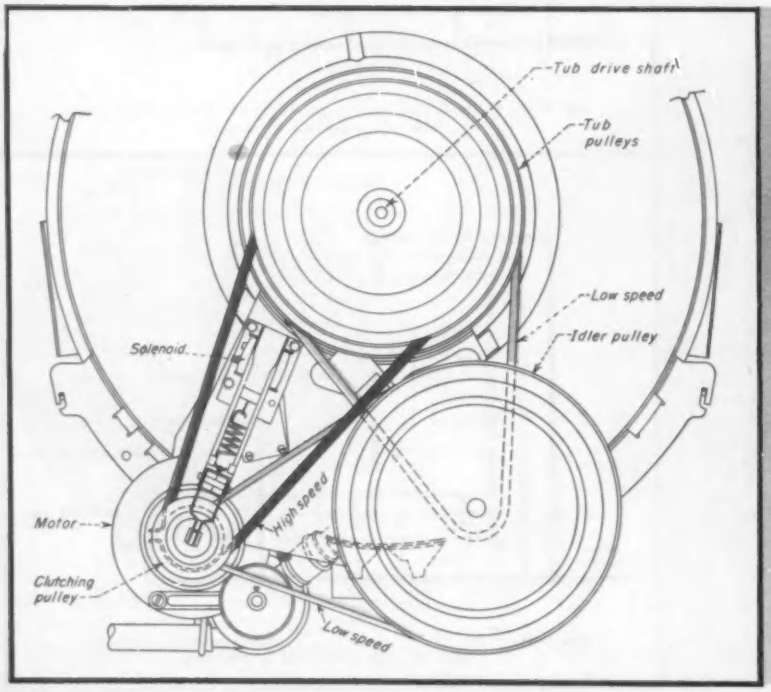
REGENERATION—After a timed period, the backwash solenoid valve is de-energized and closes. The brine and rinse solenoid valve is energized and opens to allow raw water to flow through its ejector. A suction is created over the brine valve, regeneration control, by-pass and waste valves, the other valves being closed by water pressure. Raw water now flows into the already wet brine tank dissolving the brine. Brine solution formed then flows down over the zeolite bed to regenerate the resin. The spent solution is forced up the internal feed pipe and out the waste valve to the drain. As with backwash, part of the raw water is by-passed to maintain a supply to the household service until the cycle is completed and softening begins.



Washer and Dryer Redesigned

SINCE World War II, old Laundromat drive has consisted of a combination V-belt and two-speed gear box. Drawing shows a front assembly view of the entire drive assembled to the rear of the washer. Note that drive was made up of, besides motor, the two-speed gear box, four pulleys and two V-belts. The new drive (shown below) has one more V-belt, another pulley but eliminates the gear box.





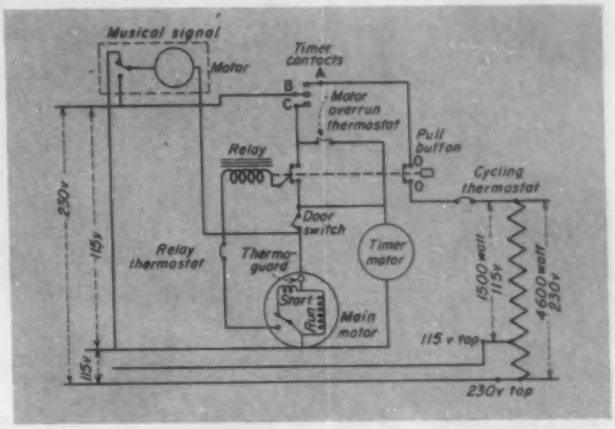
NEW LAUNDROMAT drive essentially consists of a motor, special motor pulley having one fixed and one clutching pulley attached to the motor shaft, an idler pulley and two pulleys on the tub shaft with an over-running clutch between them. Three V-belts complete the drive. For low speed, power is transmitted from the motor pulley through the idler to the tub pulley. In spin speed, drive is direct from motor pulley to the tub pulley. Speed shifting is done by a solenoid mechanism which is actuated to engage the clutching pulley on the motor shaft.

for Simplicity and Flexibility

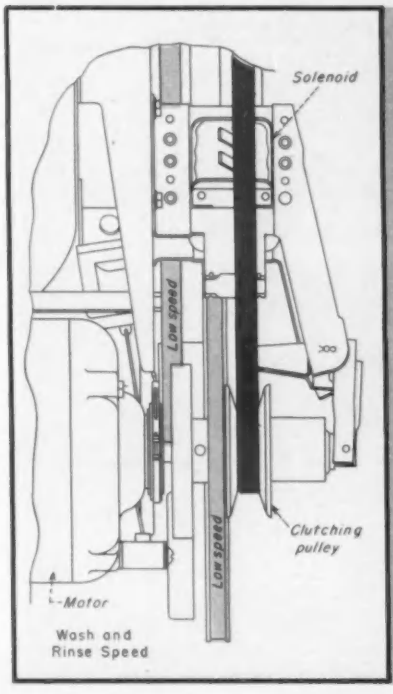
For 1954, Westinghouse has retained its distinctive styling for its automatic washer and dryer—characterized by the sloping front panel and drop door. Principal changes from last year's models are centered in a new transmission for the washer and a dual voltage arrangement with added safety controls for the dryer.

Primary reasons for the development of the V-belt drive and dropping the two-speed gear box were to offer a lower cost, quieter and easier-to-service mechanism. From a manufacturing angle, cost reduction was obtained by eliminating expensive gear cutting and precision machining. To the user, it means less cost when service is required—parts are individually less expensive and the entire drive is readily accessible for repair.

The dryer has been redesigned to permit connection to a 115 v, two-wire or a 115/230 v three-wire supply. Underlying this change is the recognition that the American people are 'on the move'. The new wiring arrangement now permits re-installation without additional wiring expense. New controls are to insure a predicted operating reliability under all conditions.

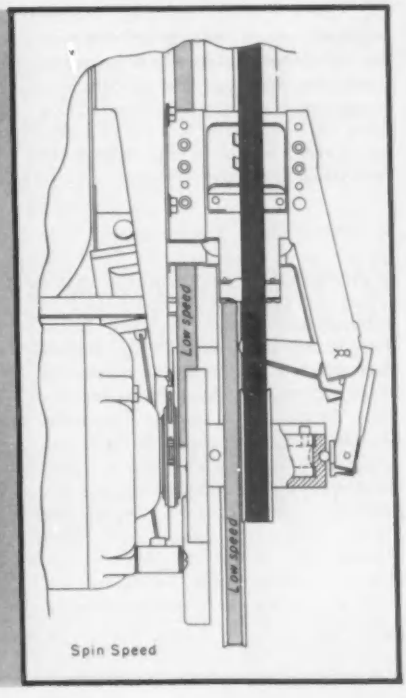


INTERNAL WIRING of the Westinghouse D-6 dryer. Temperature of the entering air to the clothes is controlled to prevent over-heating and to compensate for variations in supply voltage. A dry-dial control automatically shuts-off the dryer when the clothes are dry. A centrifugal switch built into the motor shuts-off the heater if the motor stops, and a door switch stops the dryer operation whenever the door is opened. Fastest drying is obtained when operating on the 115/230 v supply with a heat input of 4600 w. On a 115 v supply, the heat input is correspondingly longer, and since the air temperature does not rise as high, the cycling and dry-dial controls are not operative.

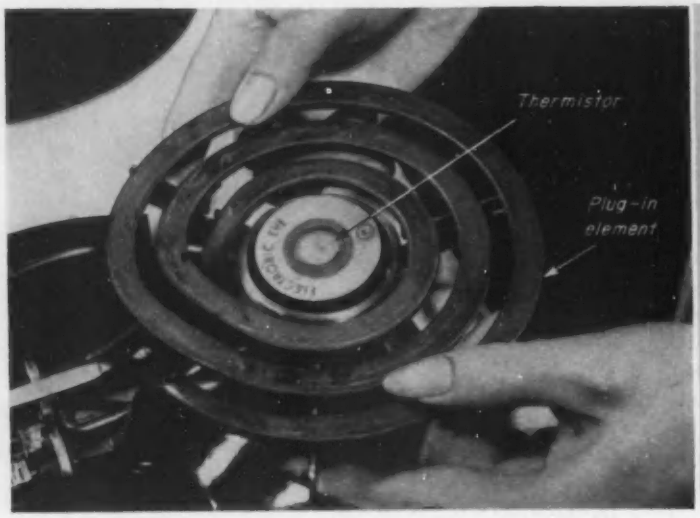


LEFT—*Wash and Rinse Speed.* For this speed, the fixed motor pulley drives to the idler pulley, and from there to the inner tub pulley. The drive is transmitted through a spring clutch to the rear tub pulley keyed to the tub shaft. Note the open position of the clutching pulley, allowing the high speed V-belt to be disengaged.

RIGHT—*Spin Speed.* To change to the 500 rpm spin stage, a timer energizes a solenoid and forces a plunger against the side of the clutching pulley. Closing it engages a V-belt which is directly connected to the rear pulley on the tub shaft. This causes the tub shaft to accelerate beyond 50 rpm allowing the spring clutch to overrun on the tub shaft.

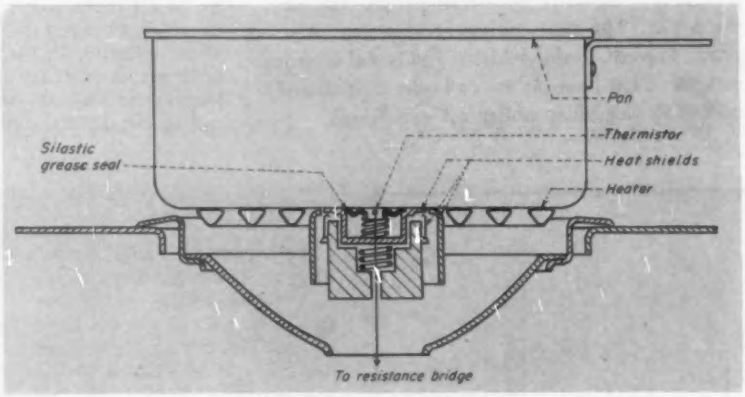


Westinghouse Ranges Adopt Electronics

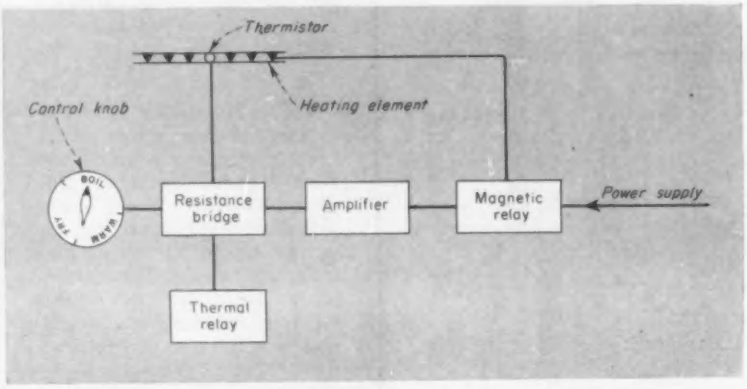


Latest step in the development of the completely automatic electric range is earmarked by Westinghouse' Automatic Corox Unit. Designed around the characteristic of a thermistor—that of a variable decrease in resistance per deg of temperature rise — the "Electronic Eye" maintains a selected cooking temperature regardless of food load, pan size, amount of water in the pan, or a variation in the supply voltage. In operation, it regulates the current flow to the heater.

CROSS-SECTION view of the range unit shows the thermistor's center position relative to the heater coils. The thermistor is completely insulated against heat transfer other than that from the pan and food temperature which it is controlling. Insulation primarily consists of an aluminum housing which contacts the pan, thereby supplying a pan bottom ambient near the thermistor button which is located inside the housing. The silicone diaphragm seals and separates the housing from the thermistor with steel baffles being used to shield and reflect the heat from the heater.



SCHEMATIC of the thermistor circuit shows the principal elements used to automatically control cooking heats. The control knob sets a bridge unbalance which is amplified and causes the magnetic relay to close the heater circuit. As the pan heats, the thermistor resistance decreases until it balances the bridge, thus opening the heater circuit. Heat is supplied as needed, the average wattage input depending upon the food's ability to absorb heat. The thermal relay is used to obtain a preselected wattage input to control the rate of boiling during the boiling operations.



Refrigerator-Freezer Unit Goes Completely Automatic

By balancing the size of the freezer and cabinet coils against the heat loss and load, Norge engineers have come up with a simplified refrigeration system for their new line of refrigerator-freezer combinations. The same refrigerant temperature is used in both coils to maintain two different compartment temperatures. This feature eliminates the need for a restrictor or weighted valve to throttle refrigerant flow between the coils.

In operation, the system is self-balancing and requires only one control to start and stop the compressor. If there is a heavy freezer load of unfrozen food, liquid refrigerant is quickly "boiled off" in the freezer coils and dry gas passes through the cabinet cooling plate. Sufficient refrigeration capacity still remains in the gas to maintain cabinet temperatures, the cutout temperature of the compressor control not reached until the freezer load is frozen. When this occurs, liquid refrigerant then flows through the system far enough to affect the control, stopping the compressor.

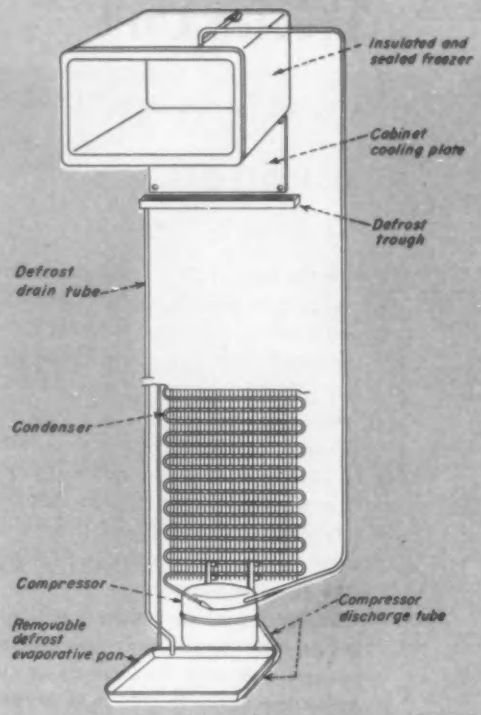
Defrosting of the cabinet plate is done after every running cycle. When the plate warms up to about 37 F, the control is actuated starting the compressor. This allows the frost to melt off on every off cycle.

DESIGN OBJECTIVES

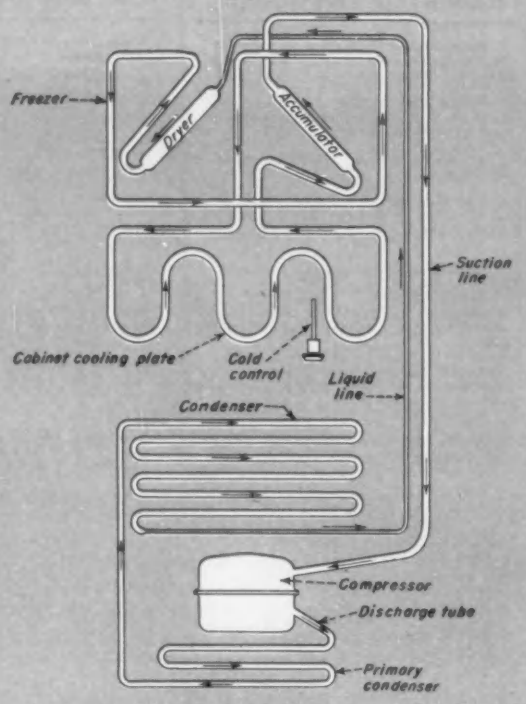
MINIMUM REQUIREMENTS SET UP	WHAT WAS DONE
1. Large freezer maintained at sufficiently low temperature to keep frozen foods for long storage periods	A separately insulated and sealed freezer compartment
2. Refrigerated storage area maintained at 38 to 42 F with sufficient humidity to prevent excessive drying of foods	A separate cooling coil employing cycle defrost
3. Automatic defrosting and defrost water disposal	By defrosting the plate on every cycle using cabinet temperature to defrost
4. Sufficient capacity to insure good recovery from either freezer or refrigerator loads in any ambient temperature	By using a properly sized plate running at a low enough temperature on the running cycle to recovery temperature quickly when the load demand is high
5. Good power consumption	A separate cooling coil empolying cycle defrost
6. Simplicity of design to insure good service life and reasonable manufacturing cost	Separate cooling coil, cycle defrost and separately insulated freezer compartment
7. A unit not requiring manual control readjustment to meet varying loads or ambient temperatures	By proper balancing of the cooling surface in the food compartment and by proper selection of control setting and location
8. A unit not overly critical to manufacturing tolerances of charge	By locating the accumulator in the cold area of the freezer and by selecting "middle of the road" control settings

TABLE above lists some of the principal design objectives that were set up in the development stage of the new refrigerator-freezer combination, and how these objectives were met. Besides where indicated, a separately insulated and sealed freezer compartment was also an important consideration for items 3 and 4. Likewise, a separate cooling coil with automatic cycle defrost was necessary for item 5.

NORGE CUSTOMATIC refrigerator-freezer combination has been designed to meet the trend toward the increasing use of frozen foods. Redesigned refrigeration system works automatically to insure rapid recovery from heavy freezer or cabinet loads. Correct temperatures (zero zone) in the freezer, and 37 to 43 F in food storage compartment, are maintained automatically, without need for control readjustments.



LEFT—Cooling of normal food storage section is done by a plate mounted at rear of the compartment. Plate defrosts on every cycle, the defrost water draining to an evaporator pan in machine compartment. Compressor discharge tubes form primary condensor which removes part of heat of hot gas to evaporate water.

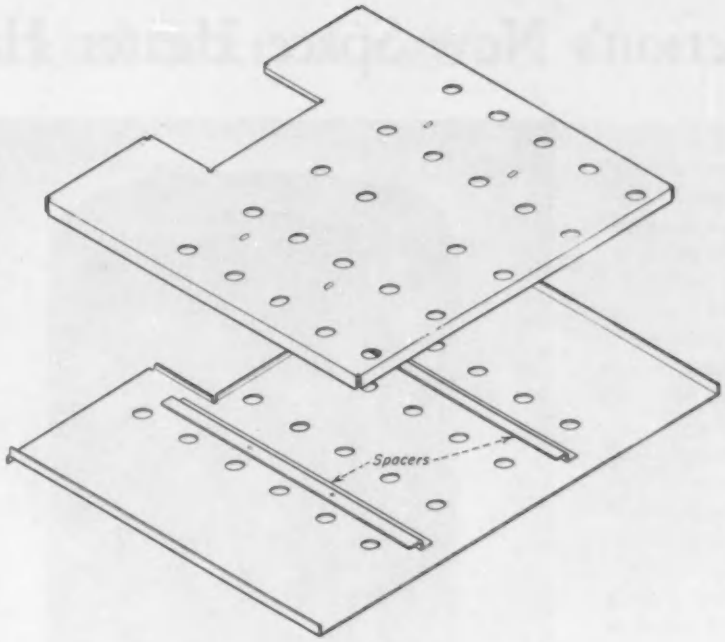


RIGHT—Refrigerant flow diaphragm shows passage of refrigerant through Customatic system. Automatic operation is based on freezer load. If load is heavy, there is insufficient liquid passing through cabinet plate to actuate cold control. When load is light, liquid refrigerant flows quickly to plate causing control to stop compressor. Food compartment or storage loads compliment this system of automatic control.

Norge Simplifies Dryer Cylinder Design and Mounting

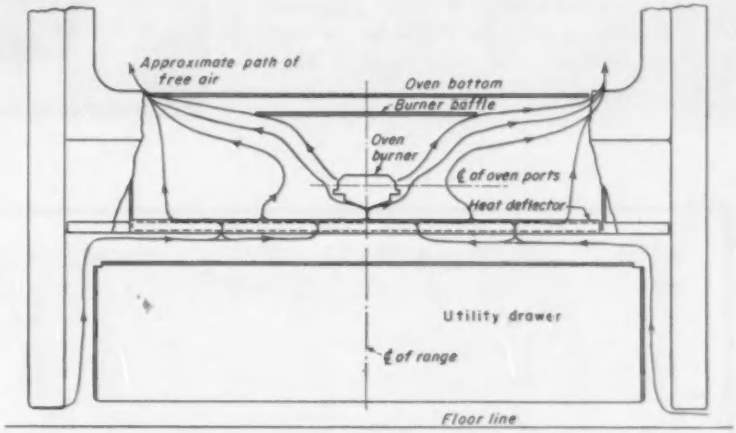
LEFT — Three-point cylinder suspension used in Norge dryer simplifies the outboard bearing support and problem of supporting heavy combined weight of cylinder and fan. Besides keeping dryer cylinder in alignment and balance, method of suspension gives a ready means to stop rotation for static drying. Cylinder is supported on stub shaft at rear, and two 4 in. dia rubber wheels. For stationary drying, cylinder is raised off drive pulley by steel bar lift mechanism.

RIGHT—Norge simplifies its dryer design with a combination cylinder and blower assembly. In operation, 21 in. dia blower forces heated air through three ducts into back of cylinder. This arrangement makes possible stationary drying because of even distribution of heat, and also prevents lint backing up and contacting heat source. Sirocco blower is fabricated from 18 gage steel, cylinder is 20 gage, both double Epon-coated.



EXPLODED VIEW of baffle arrangement illustrates simplicity of design, effective and relatively inexpensive to manufacture. Bottom element of the unit has four rows of 1 in. dia holes, top section has five equally sized rows. When assembled, the holes are staggered to channel the free flowing air under and between the deflector surfaces.

FRONT cross-section view of Tappan's 30 in. range shows general arrangement of heat deflector sandwich between utility drawer and oven burner compartment. Air drawn into range along sides of utility drawer passes over top of drawer entering four rows of holes in deflector bottom section. Staggered rows of holes causes air to loop between sections to pass through holes in top, thus setting up a complete air insulation cushion.



Tappan Stove Uses "Baffle-Sandwich" as Heat Deflector

Two flat sheet metal stampings separated by ⅛ in. spacer ribs and perforated to give an indirect air flow when assembled serve to effectively prevent heat transfer from the gas burner compartment down to the utility drawer of Tappan Stove Company's new Holiday range.

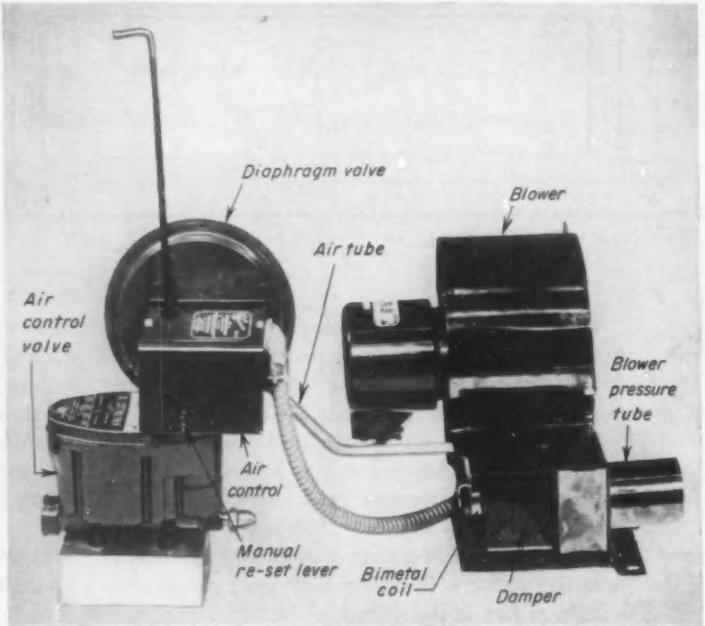
Designed to permit storage of kitchen equipment regardless of burner heats, the deflector unit is positioned directly under the oven burner, about 2 in. from the centerline of burner ports and 1 3/32 in. from top of utility drawer.

Evaluated in temperature differential, the deflector is capable of deflecting sufficient heat from the burner compartment to permit only a slight pickup in the storage section. At a burner compartment temperature of approximately 750 F, utility drawer reaches only 90 F.

Perfection's New Space Heater Has

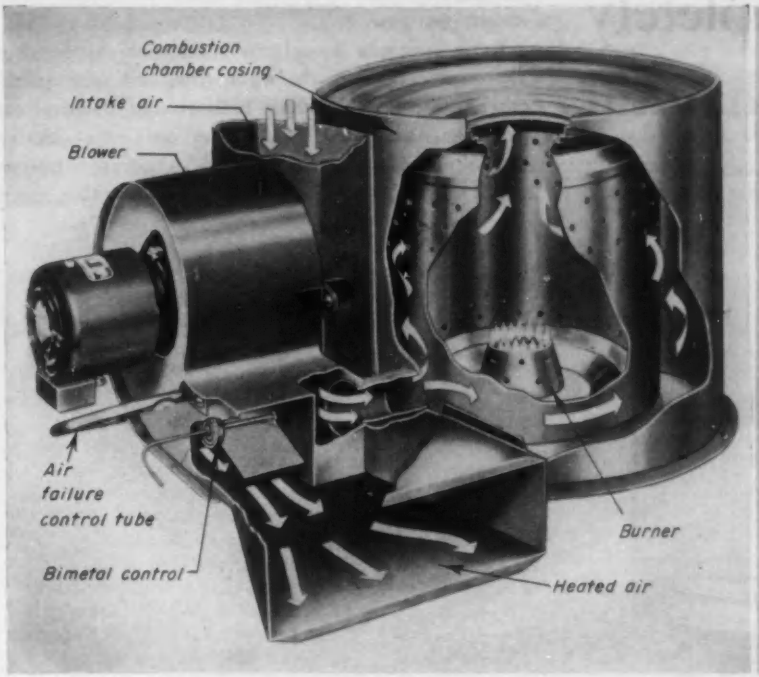
A new oil-fired space heater, recently developed by the Perfection Stove Company, Cleveland, Ohio features a new type air failure control that, in the event of power failure or faulty motor operation, acts to automatically reduce the fuel supply to the burner. This prevents smoking, fire hazard or carbon deposit in the combustion chamber and burner bowl.

Another control—previously used only on the larger Perfection furnaces—balances the flow of warm air at the floor level with the amount of heat issuing from the duct on the combustion chamber. To assure a more complete burning of the fuel, the heater also incorporates a draft design that synchronizes the draft supplied to the burner with the oil flow. The correct amount of draft is created regardless of chimney size, type of weather, or similar conditions that affect natural draft.



AIR FAILURE control consists of a diaphragm valve which is operated by the air pressure bled from the blower scroll housing. During normal operation, the air pressure holds the metering valvestem of the oil control device off its seat. If the current fails, the motor stops or the blower fan becomes loaded with lint, the reduction in air pressure allows the valve to seat, thereby shutting-off all but a pilot fuel supply to the burner. Another feature of the control is that at the time of extended power failure or air failure, the manual reset lever can be positioned to permit the heater to operate up to 50 percent of its rated output.

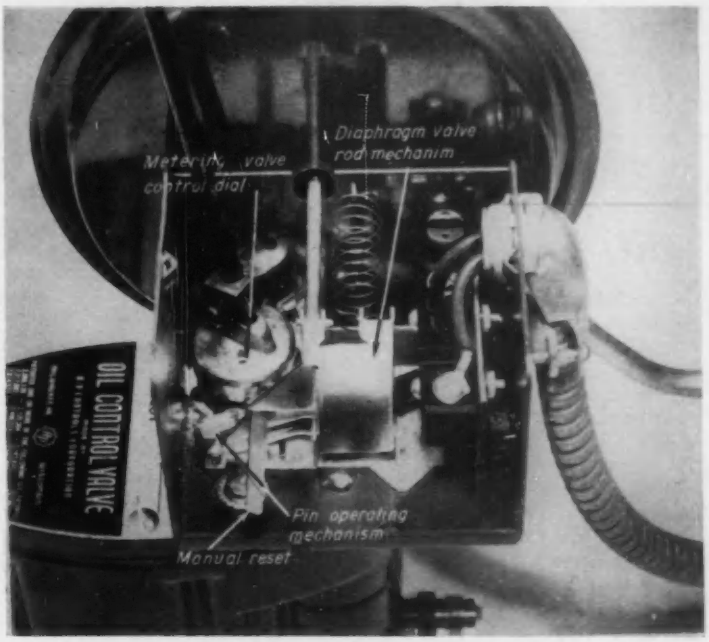
Added Safety Controls



BURNER and blower assembly view shows the path of air through the heater. Air for both room heating and combustion is drawn into the intake duct in contact with the combustion chamber. Heat conducted through the chamber warms the air. The warm air goes through the blower and is separated so that part is channeled to the duct around the burner and the rest is discharged into the room. Note bimetal element which is used to control the damper operation.

THE OIL CONTROL valve is actuated by a mechanical linkage which, in turn, is operated by a rod attached to the diaphragm valve. The mechanism contacts a control pin to open and close the metering valve stem of the oil control valve. With the proper air supply to the heater, the oil control valve stem is free to pass any amount of oil that is required or that the control dial is set for.

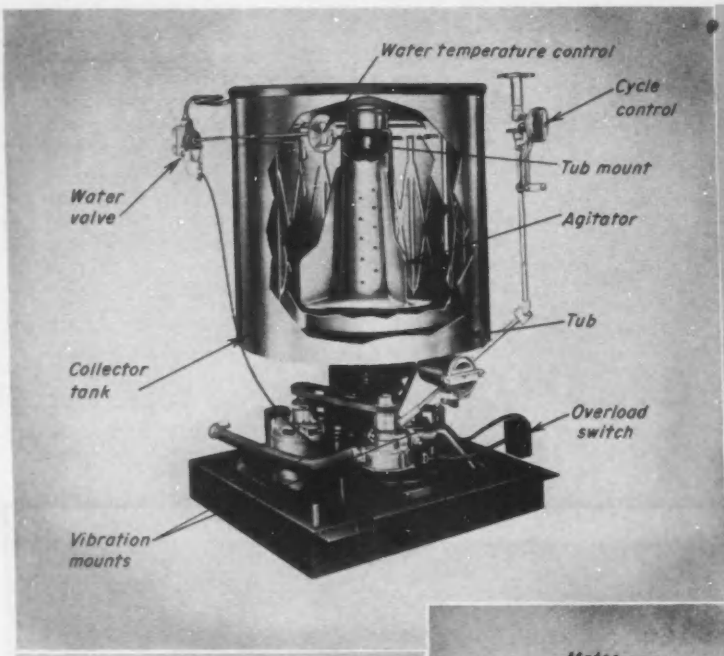
There is also a switch located in the air control unit which turns the blower on and off. This switch is actuated through the setting of the oil control valve, either manually or with thermostatic room temperature operation.



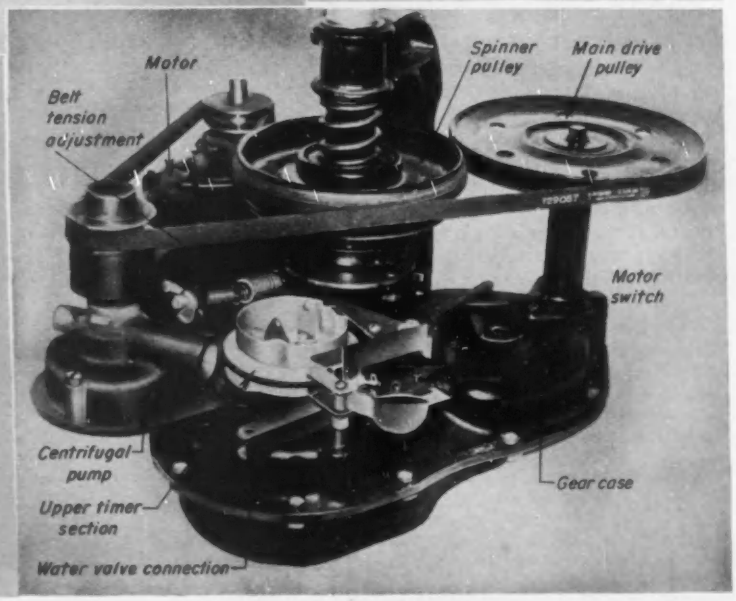
Blackstone Washer Stays Completely Mechanical

In the redesign of their automatic washer, Blackstone Corporation, Jamestown, N. Y., has retained its mechanical timing and control system—principal changes being centered in a more compact timer assembly of increased operational flexibility and a substantially lower weight gear case.

Representing a completely mechanical approach to automatic control of the wash, rinse and spin cycles—other washers are generally built around electrical control—the redesigned model uses only one electrical control element, a precision switch to operate the motor. Other operations such as opening the water valve, raising



BELOW—View of drive assembly shows motor cradle-mounted on a swinging saddle. During the wash and rinse cycles, motor drive is transmitted directly to the main drive pulley which drives the agitator mechanism located inside the gear case. At spin speed, agitator drive has been disengaged by the main timing cam (not shown) and spinner clutch has been raised to engage spinner pulley. Centrifugal pump operates continuously through all cycles. Note upper section of mechanical timer protruding from gear case. Also shown are motor switch and water valve cable connection, both of which are actuated by upper cam section.



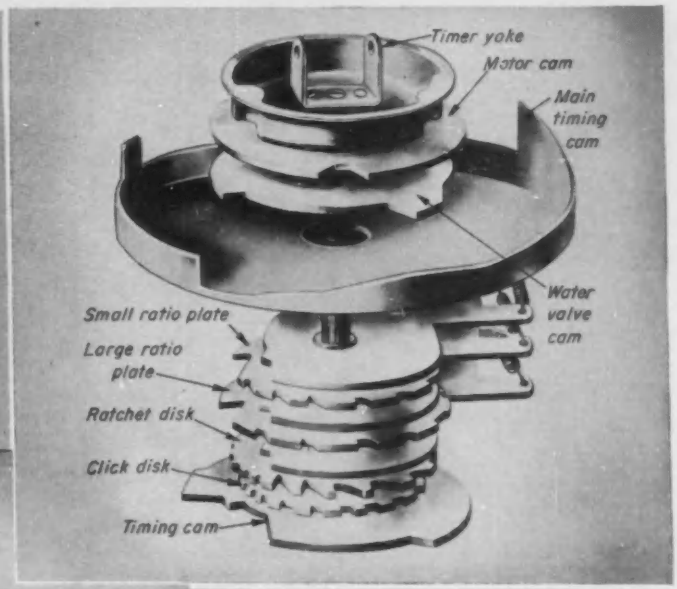
ABOVE—Phantom view of the Blackstone washer shows the entire mechanism mounted on three cushion-rubber mounts to absorb vibration preventing transfer to base or cabinet. Also shown is the flexible rubber ring which supports the tub. The ring permits a shaft tilt in any direction to allow the tub to find its own center of gravity. Collector tank encloses agitator and tub, and collects water spun off from tub for discharge to drain.

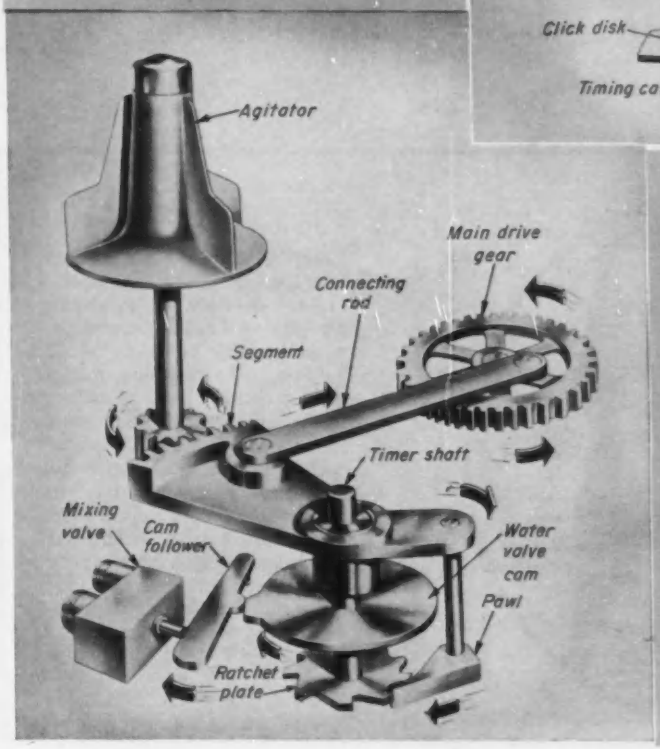
and lowering the tub, and shifting the drive from wash to spin speed is accomplished mechanically.

Control over the complete washer operation is designed into a series of flat steel cams and attached ratchet plates forming a timer assembly. A pawl driven by the agitator drive mechanism rotates the ratchet plates to advance the control cams through the various cycles. Length of cycle is a function of the number of teeth in the ratchet plates. Shortening or lengthening of the cycle is obtained by moving the control cams relative to the plates, cams being moved through a linkage from the cycle control knob on the machine cabinet. Also, hot and cold water mixing is done mechanically as is opening of the valve. Mixing valve consists of two hot and cold water poppet valves controlled by an axial cam. Cam position determines the relative depression of one valve stem to the other.

To raise or lower the tub, the bottom of which forms the water seal between tub and collector tank, to disengage the spider drive at the top of the agitator, a master cam having irregular contours is used. The agitator's drive shaft, one end holding the spider and the lower end following the cam contour, is raised or lowered as the cam rotates about the time assembly shaft.

BELOW—Simplified isometric sketch illustrates water valve operation. Other cams control motor, raising and lowering of shafts. For operation shown, motor is geared to main drive gear which by means of connecting rod reciprocates gear segment for agitating action. As segment reciprocates, a pawl attached to other end engages the teeth of a ratchet plate rotating it about a timer shaft. Water valve cam moves with plate until cam lobe contacts lobe on cam follower to depress mixing valve stem. This opens valve admitting water to the tub.





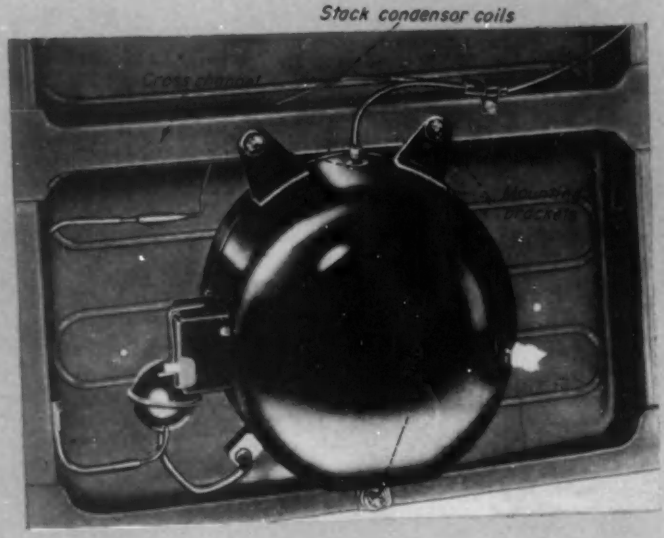
ABOVE—Heart of automatic washer is the timer mechanism, a combination of steel cams and ratchet plates which function to: (1) turn the motor on and off; (2) open and close the water valve; and (3) raise and lower the tub for washing, draining and spinning. Movement from one cycle to another occurs when the deep-cut teeth of the two ratio plates align. This permits a pawl driver from the agitator drive mechanism to drop into a tooth in the ratchet disk rotating it and attached timing cam to actuate the next cycle.

Manual control is obtained by rotating the timer shaft yoke and attached motor, water valve and main timing cams. Relative position of these cams with respect to the ratio plates and timing cam determine the cycle desired and duration.

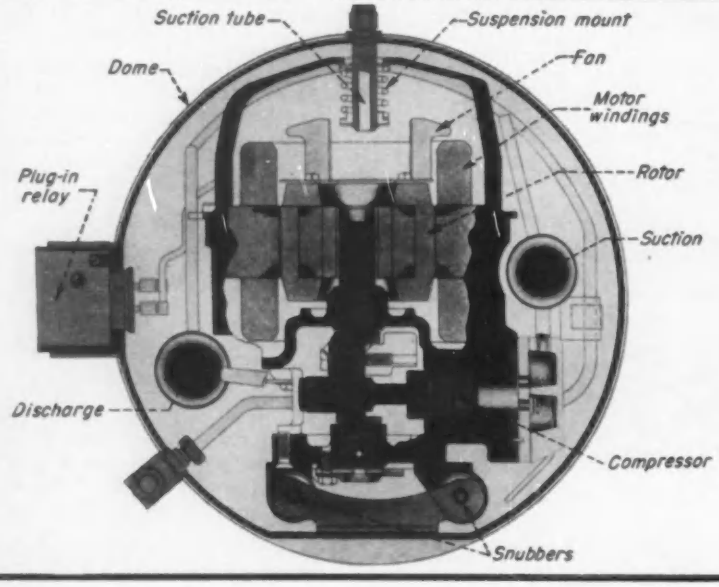
Kelvinator Redesigns Sealed Compressor Unit

By changing from an external to internal mounting for their hermetically sealed motor-compressor assembly and redesigning component parts for greater servicing ease, Kelvinator Division of Nash-Kelvinator Corporation has produced a new unit that is quieter in operation and easier to maintain than predecessor models.

Formerly, compressor mounting consisted of a single point of suspension from the top of the sealed dome with twin snubbers used at the sides of the compressor to absorb starting and stopping torque reactions. New



INTERNALLY suspended compressor is fastened to the stack condensor cross channels, dome being fitted with two attaching lugs at top and one at the bottom. Note the absence of vibration loops in the tubing which are common to externally suspended compressors.

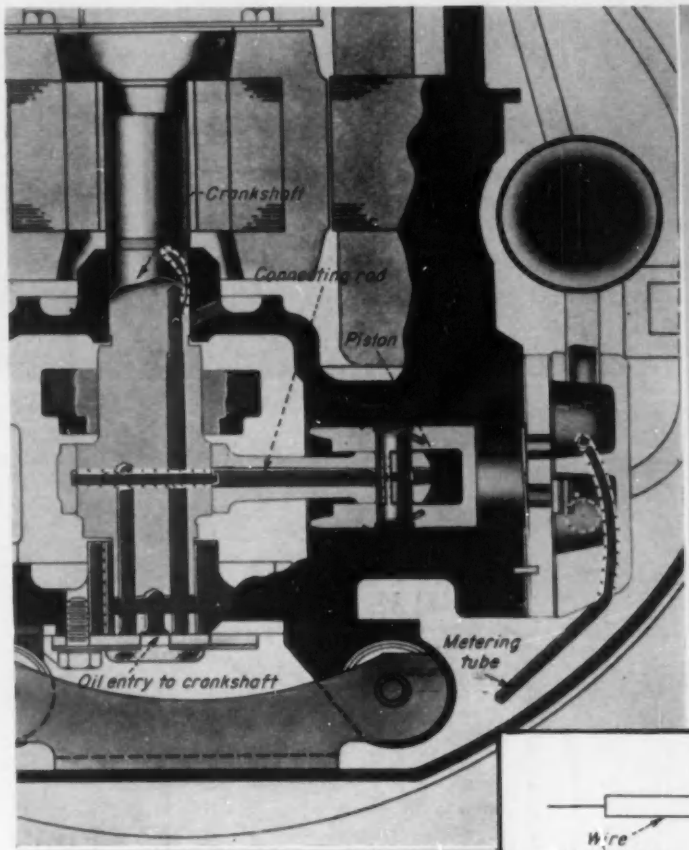


CUTAWAY of dome shows internal suspension of motor-compressor assembly. Also shown are intake and exhaust mufflers to minimize noise caused by piston pulsations. In operation, refrigerant is returned through suction tube where liquid is directed over motor windings and compressor body. Fan attached to motor rotor then whirls refrigerant to dome walls to speed up dissipation of motor heat. Additional internal cooling is obtained by the large oil reservoir in the bottom of dome which also conducts heat to the inner dome walls.

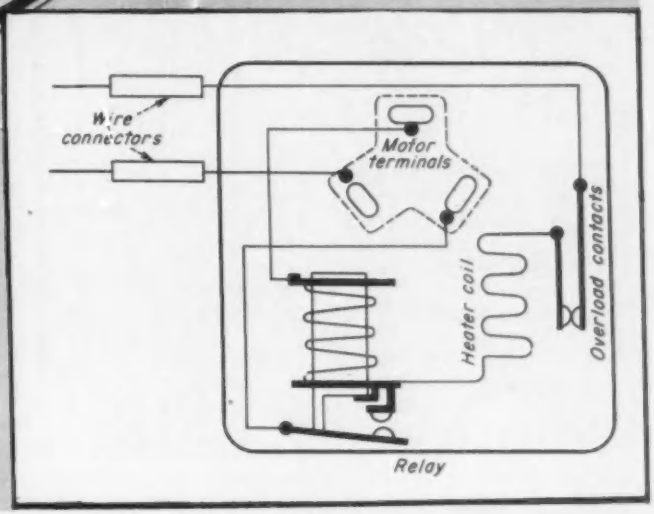
design "floats" the entire mechanism on a single suspension spring from the top of the dome, torque stabilizers used being essentially the same. Dome is now rigidly mounted to the unit frame, eliminating possibility of vibration loosening connecting lines or damaging compressor if shipping bolts are not removed. A suction muffler has been added to absorb a portion of the noise resulting from the pulsating effect of the compressor piston, an exhaust muffler already being used.

To improve servicing, all parts requiring maintenance —valves, relay and capacitor—are located on one side of the unit for easier accessibility. A new plug-in type starting relay and thermal overload replaces a conventional separately mounted device, eliminating motor leads and allowing simple removal for checking or replacement.

For those installations not using a stack condenser, the sealed compressor unit operates in conjunction with a newly developed nested fin-type condenser. The fins are designed and extruded so that the tubes are an integral part of the whole assembly.



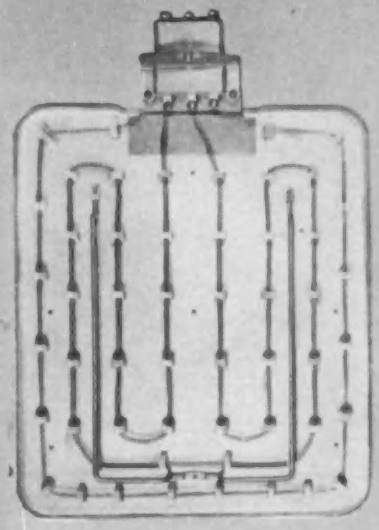
LEFT—Pressure-feed lubricating system adds to quiet operation by forcing oil to every moving part and flooding bearings to minimize friction. Oil from reservoir enters through opening in thrust plate and into crankshaft. From crankshaft, oil flows to upper bearings, connecting rod bearing and through rod to wrist pin. Metering tube introduces measured quantity of oil into the cylinder at each piston stroke.

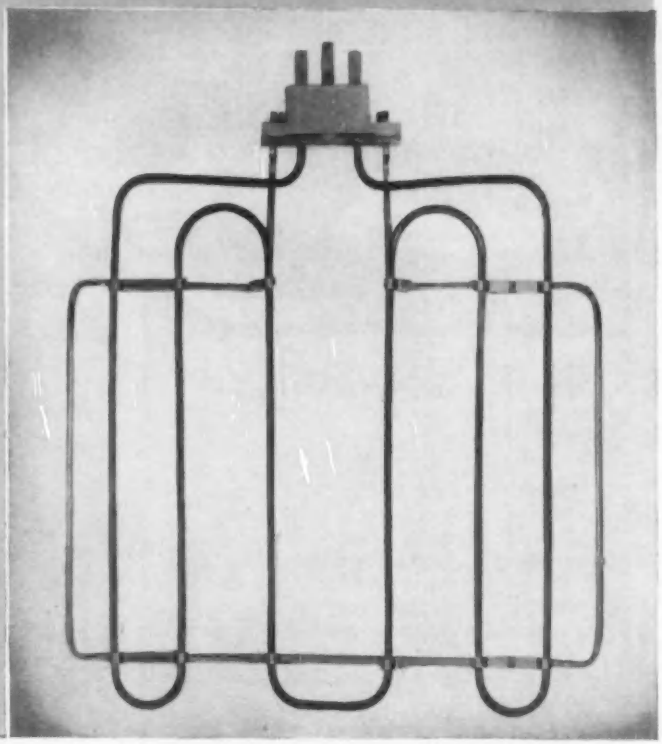


RIGHT—Dome mounted relay simplifies wiring system, the cabinet wiring harness plugging directly into relay terminals. By mounting relay on dome, bimetallic thermal overload tripout device functions not only to protect against an excessive motor winding current rise, but also against an abnormal temperature condition inside the dome.

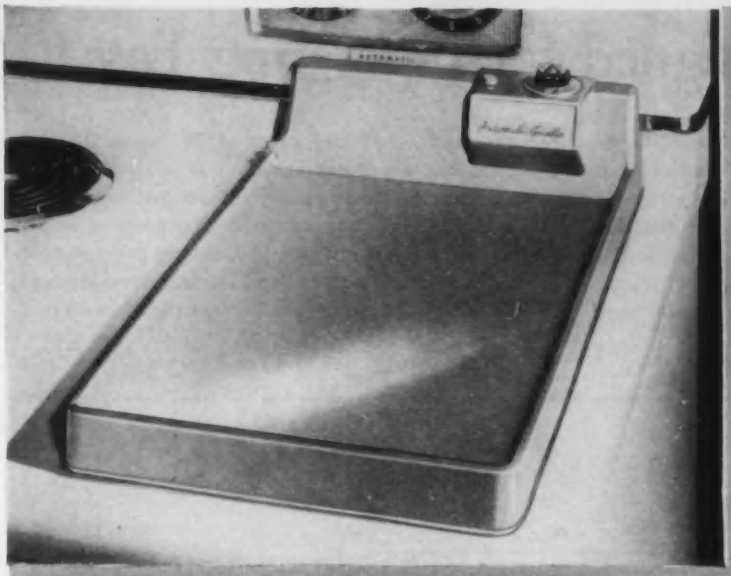
Hotpoint Stresses Plug-In Design

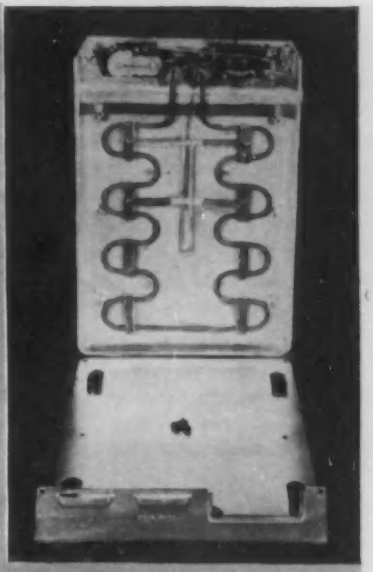
HOTPOINT'S entry in the 1954 deluxe range market is the RD-22 pictured above. Among new features of top-lighted push-button controlled range are unbaffled, plug-in Calrod oven units, and a plug-in thermostatically controlled surface griddle. Calrod surface units have also been reduced in size to give a 15 percent faster response to heat and a correspondingly quicker cooldown.





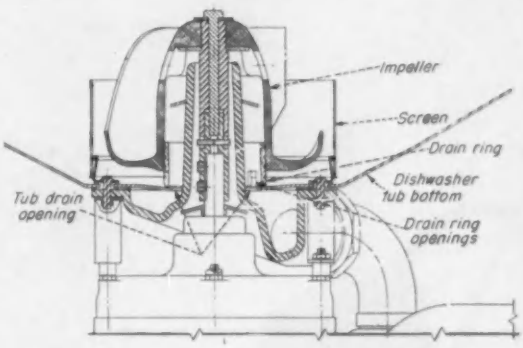
OLD AND NEW Calrod oven units. Replacement of the open coil baffled broil and bake units by new unbaffled elements results in an increase of approximately 500 cu in. of usable oven capacity. Besides better heat distribution, new design gives more uniform "browning" and permits reduction of more than 800 watts for baking operations. Other advantages are lighter weight and easier cleaning.





PLUG-IN griddle gives range user an additional 175 sq in. of thermostatically controlled cooking surface. A 2,000 watt Calrod heating unit clamped to the underside of the cast aluminum plate supplies heat of 195 to 395 F, control over which is maintained by a hydraulic type bellows instrument. Plug-in feature and lightweight simplifies use, cleaning and storing of griddle to free range work surface.

New "Plug-In" Dishwasher

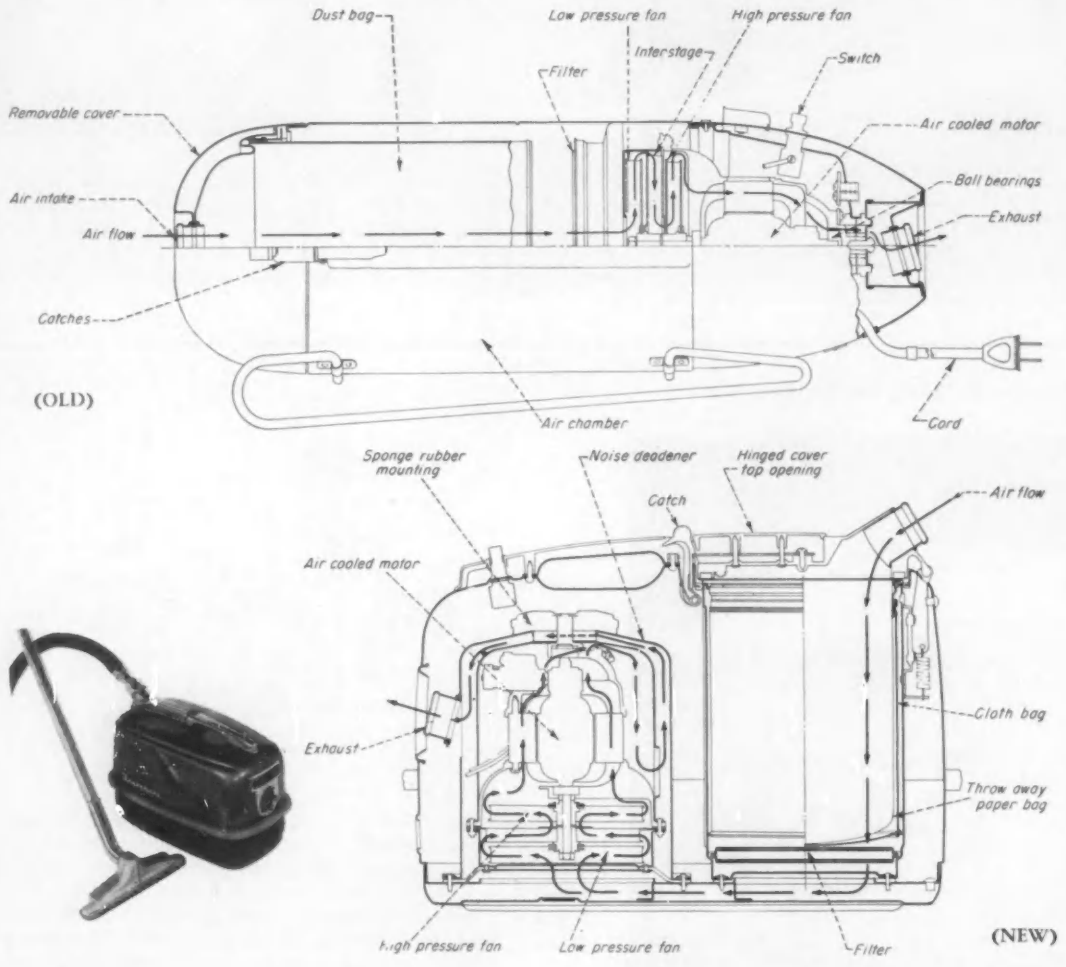


ABOVE—Cross-section of dishwasher mechanism explains operation of simple drainage arrangement. Drain ring rotates with impeller and since ring contacts tub surface outside tub drain opening, prevents water from reaching drain passage. When impeller is stopped, water passes through several slots in bottom edge of drain ring entering tub drain opening for discharge.

LEFT—Hotpoint's new mobile automatic electric dishwasher has been designed as a full-size unit, easily converted for permanent installation. Requiring no special plumbing or wiring, dishwasher retains all features of present permanently installed units. One such feature carried over to new line is gravity drain principle which uses no valve or moving parts to empty tub.

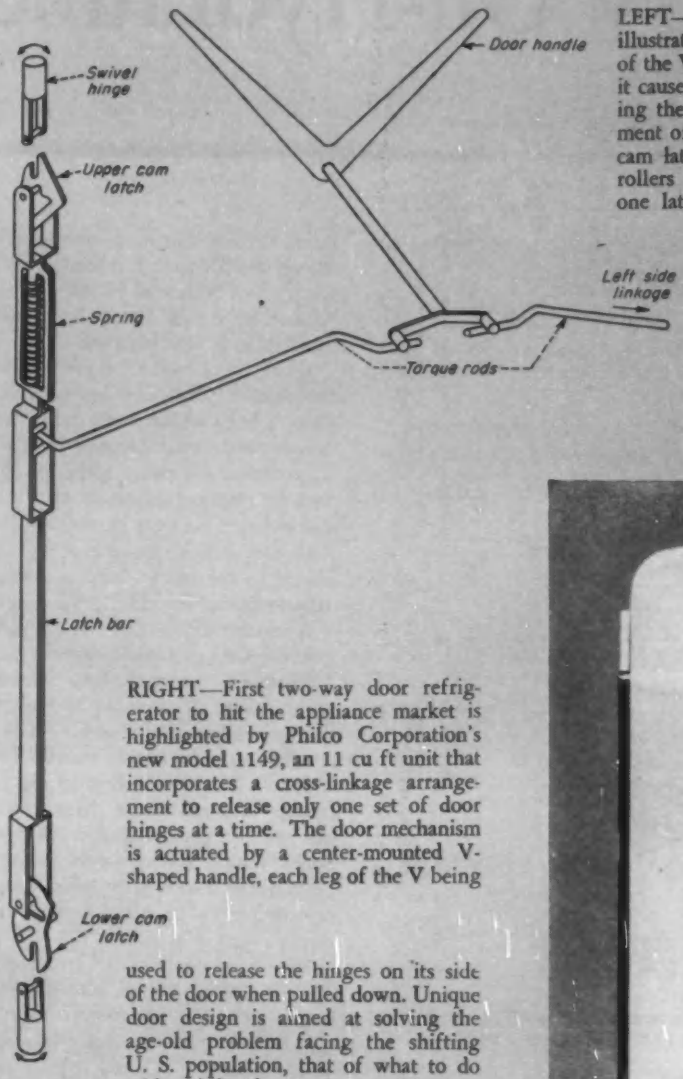
Cleaner Redesigned for Operating Ease

Claimed to be the most recent development in the evolution of home vacuum cleaner design, Landers, Frary and Clark's new cleaner model emphasizes the rapidly increasing trend for greater ease in appliance operation. Compared to previous models, the new unit has approximately the same general performance characteristics—a 65 in water lift, 60 cu ft of air displacement per min, and a full load input of 700 watts. The big change, about which the cleaner was completely redesigned, is the means to simply remove and replace the dirt bag. A sliding type catch holding down a hinged cover now gives a quick access to the bag compartment. Previously, bag removal involved loosening two luggage-type latches and removing a portion of the cover section.

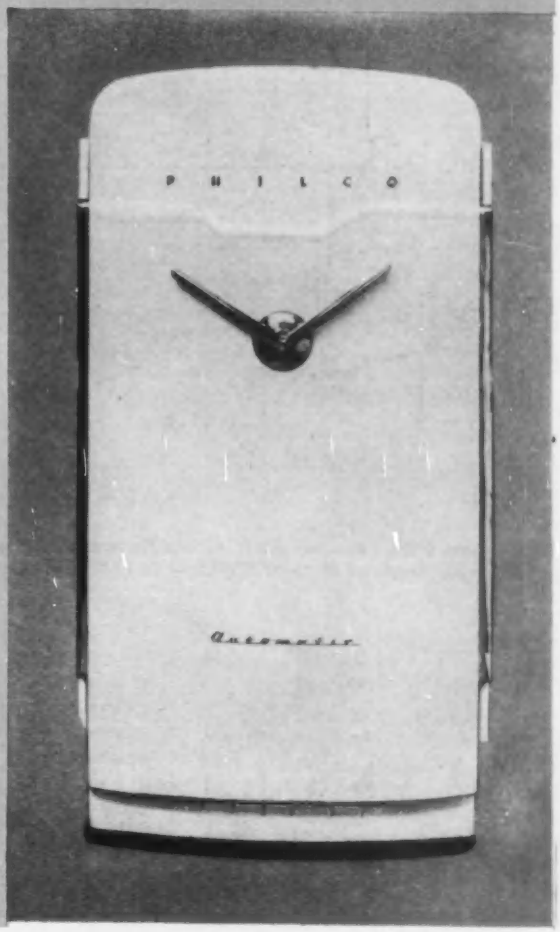


COMPARATIVE cross-section views of the old and new cleaners shows the extensive re-arrangement of components to achieve an easier bag removal operation. Designing for this feature also permitted adoption of newer production techniques to offset production and tooling costs. Noise level was also reduced in the new model. Designated as the Jet 99, the new cleaner weighs one lb more, is about 3 in higher, but gains over 5 in in length. Relocation of components also gave a better balance to permit less effort in pivoting the base to follow the cleaning operation. Insert shows picture of new cleaner with typical cleaning tool attached.

Philco Designs Two-Way Refrigerator Door

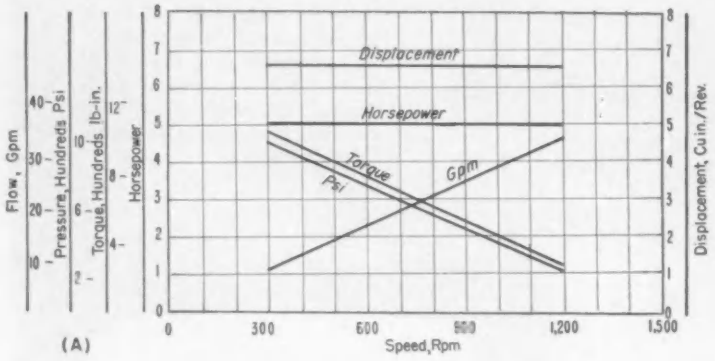


LEFT—Sketch of the hinge arrangement illustrates the door operation. When one leg of the V-shaped door handle is pulled down, it causes the offset torque rod to rotate forcing the latch bar down. Downward movement of the bar results in the release of the cam latches through movement of the cam rollers in the enclosed cam contours. Only one latch bar is moved down at any one time. The hinges are the swivel type and spring loaded to return to the normal latch position. Spring located near the top of each latch bar supplies the latch closing force and once latches are disengaged, reposition latches for door closing.



RIGHT—First two-way door refrigerator to hit the appliance market is highlighted by Philco Corporation's new model 1149, an 11 cu ft unit that incorporates a cross-linkage arrangement to release only one set of door hinges at a time. The door mechanism is actuated by a center-mounted V-shaped handle, each leg of the V being used to release the hinges on its side of the door when pulled down. Unique door design is aimed at solving the age-old problem facing the shifting U. S. population, that of what to do with a left-side opening model when the new space arrangement dictates a right hand opening unit. Other claims advanced by the manufacturer are convenience to the user and freedom of action for the home decorator. Not insignificant is the curiosity appeal it will have to the public, a factor that steps up the traffic in dealer's stores.

Selecting Rotary Oil-Hydraulic



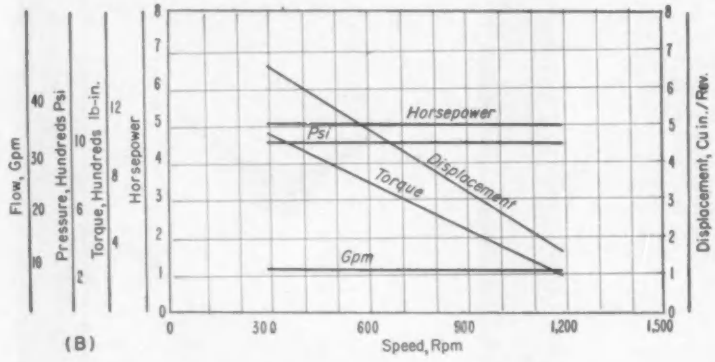


Fig. 1—Performance characteristics of a fixed displacement hydraulic motor (A) and a variable displacement motor (B). Note in (A), flow increases with speed.

MILTON R. FOX
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THE FIELD OF APPLICATION for oil-hydraulic power is broadening with increasing rapidity. From a position of secondary importance as power transmission devices, oil hydraulic motors have, in the past decade, replaced many types of mechanical transmissions and been used to supplement electric and combustion engine drives. Because of their adaptability to wide ranges of operating conditions and because of significant improvements in both equipment design and circuitry, they have been used to improve operation in many types of machinery.

There are two general classes of rotary hydraulic motors: fixed displacement and variable displacement. The fixed displacement type has a fixed torque capacity directly proportional to the applied pressure. It is used in many applications because of its low cost and because its design simplicity permits installation in limited space.

If the torque load to be exerted over the useable speed range is nearly uniform, a fixed displacement motor will operate with corresponding uniform oil pressure. Necessary speed changes must be obtained by means of a variable delivery pump or by controls that alter the useable amount of oil delivered to the motor from a constant delivery pump.

A variable displacement motor functions the same as would a cylinder were it possible to change the bore diameter conveniently. Motors can be built so that the amount of oil they use for each revolution can be readily varied. This is done where it is desired to use the change in performance characteristics that go with displacement changes. Speed varies inversely with displacement and as shown in the table, torque capacity per 100 psi varies directly with displacement, Fig. 1(B).

Where the load to be driven presents a varying torque with approximately constant horsepower over a speed range not exceeding 4:1, and where the power capacity is to exceed 5 hp, the variable displacement motor usually is used. On lower horsepower applications, the problems associated with the use of a fixed displacement motor can usually be easily met.

The following example of a borderline power application will illustrate the benefit of the variable displacement motor for a variable torque job. Assume that a milling cutter spindle is to be rotated at speeds from 300 to 1,200 rpm, and that the power re-

Motors

quirements are for 5 hp over the full speed range. This means that the torque requirements (Equation 1) are 1,050 lb-in at 300 rpm, and 262 lb-in at 1,200 rpm. If a fixed displacement motor were used and the oil supplied at 1,000 psi, the required displacement by Eq. (2) is

$$\text{Displacement} = \frac{1{,}050 \times 100}{1{,}000 \times 16} =$$

6.6 cu in./rev.

The oil circulation rate at the extremes of the speed range would be,

$$\text{At 300 rpm } \frac{300 \times 6.6}{231 \text{ cu. in./min}} = 8.6 \text{ gpm}$$

$$\text{At 1,200 rpm } \frac{1{,}200 \times 6.6}{231} = 34.4 \text{ gpm}$$

The oil pressure required at 1,200 rpm would be

$$\text{Pressure} = \frac{T \times 100}{D \times 16} =$$

$$\frac{262 \times 100}{6.6 \times 16} = 250 \text{ psi}$$

An oil pressure of 250 at 1,200 rpm is favorable but the volume requirements of 34.4 gpm requires large lines and valves as well as a large pump and may be objectionable.

If the motor displacement might be reduced to one-fourth of the 6.6 cu in. per revolution required at 300 rpm, then 1,200 rpm could be obtained with the same flow, and the oil pressure would remain at 1,000 psi. Smaller lines, valves and pumps would be possible. A graphic illustration of requirements for driving the above constant horsepower load are shown in Fig. 1(A) for a fixed displacement motor, and in (B) for a variable displacement unit.

Specific applications of constant and variable displacement motors entails analysis of many additional variables. The following examples have been selected for discussion because of the range of problems they present.

CONSTANT TORQUE CONVEYOR DRIVE. In an application of this type, the load, or torque, is essentially uniform, but some flexibility in speed is desirable. Speed change with a constant displacement hydraulic motor can be accomplished by either one of two methods of varying the oil delivery.

The method that involves the lower initial investment is shown in Fig. 2(A). The constant delivery pump may be a vane type or other relatively inexpensive type. Its delivery may go to both the motor and to the flow control valve shown. If the valve is in the "off" position, full delivery flows to

HOW STRAIGHT LINE AND ROTARY MOTORS COMPARE

Rotary motors are essentially the same as cylinders to the extent that they present an exposed area to an imposed oil pressure. Power output is determined by the torque developed and the rate at which it is utilized:

$$Hp = \frac{T \times S}{63{,}025} \qquad (1)$$

where T is torque in lb-in. and S is speed in rpm. With electric motors, the rpm is fixed at either of several available values. With such fixed speed, the power output is a function only of the torque and it is therefore convenient to rate such motors by their power capacity. With hydraulic motors where both speed and torque are likely to be variable, a horsepower rating might be deceiving and a torque rating is therefore more common.

Motor Displacement—Cylinders are usually rated by bore diameter. Displacement can be obtained from any known diameter, and when multiplied by speed of operation, equals flow capacity required.

An exact parallel exists with rotary motors: Flow can be calculated from displacement per revolution and per unit of time.

Torque—Displacement Relationship—The relationship between displacement and torque of a rotary hydraulic motor is fixed, and equals approximately 16 lb-in. of torque per cubic inch displacement for each 100 psi increment of pressure—assuming 100 per cent motor efficiency. Thus,

$$T = \frac{D \times P \times 16}{100} \qquad (2)$$

where T = Torque, lb-in.
D = Displacement, cu in./rev.
P = Oil pressure, psi

Operating Efficiency—Operating efficiency of a motor is highest when it is operating at or near rated speed and torque. Maximum efficiency will vary all the way from about 75 to 95 per cent depending on the type of the motor. Efficiencies of gear and vane type motors usually are between 75 and 85 percent with the piston type being somewhat higher. Piston motors, with their closer running tolerances, range from 90 to 95 percent efficient.

Of course, the overall efficiency of a drive utilizing a hydraulic motor at the output end is dependent on the accumulated efficiencies of all of the components of that drive, such as the electric motor, the drive from electric motor to the pump, the pump, oil circulation through lines and valves, and finally that of the hydraulic motor itself. Too often hydraulic motors are blamed for low efficiency which properly should be attributed to other parts of the circuit.

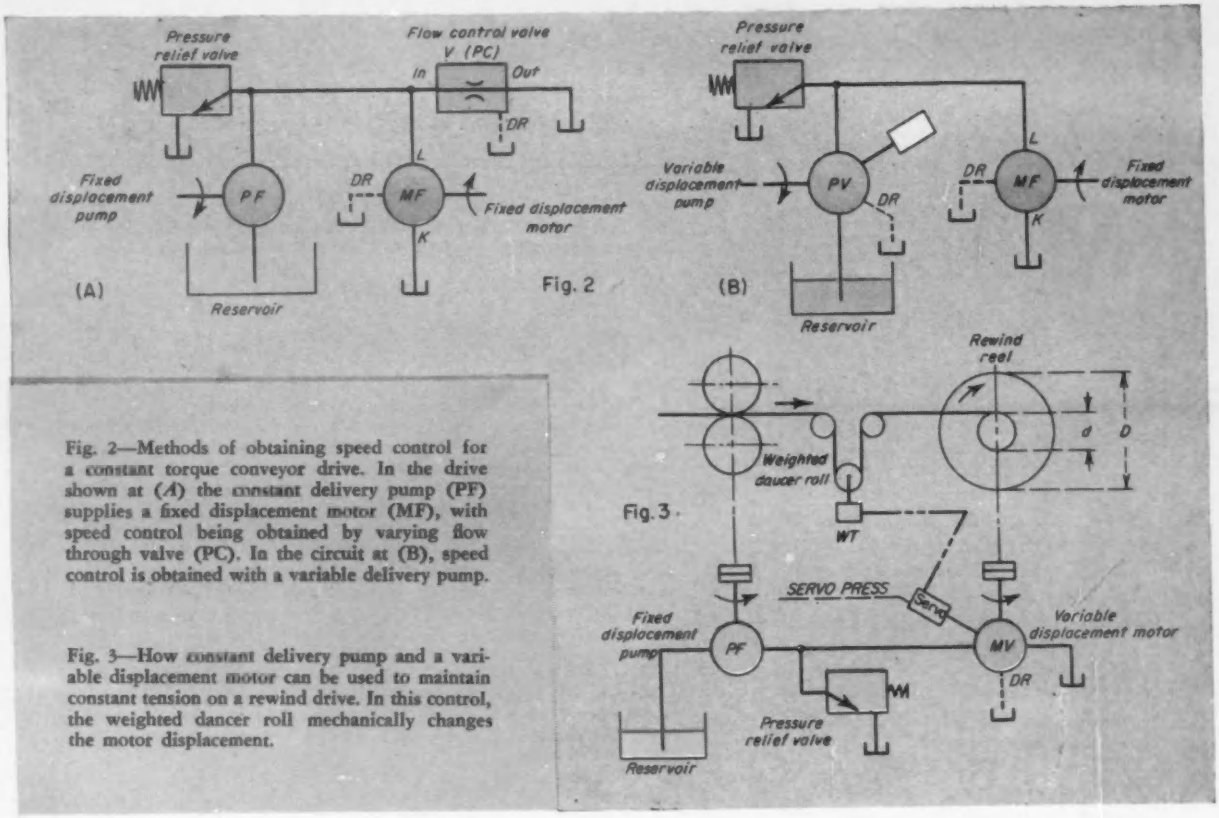


Fig. 2—Methods of obtaining speed control for a constant torque conveyor drive. In the drive shown at (*A*) the constant delivery pump (PF) supplies a fixed displacement motor (MF), with speed control being obtained by varying flow through valve (PC). In the circuit at (B), speed control is obtained with a variable delivery pump.

Fig. 3—How constant delivery pump and a variable displacement motor can be used to maintain constant tension on a rewind drive. In this control, the weighted dancer roll mechanically changes the motor displacement.

the motor and maximum speed results. If the valve is in the "opened" position, the motor receives pump delivery minus the amount of fluid passing through the valve. The working pressure is always a direct function of the torque load on the motor; the relief valve is for overload protection only.

The amount of oil passing through the flow control valve and the amount of the working pressure determine the amount of wasted energy. If one-half of the pump delivery is passed through the flow control, then one-half of the power delivered by the pump is wasted.

This wasted energy will show up in the form of heat in the oil. If the oil temperature is permitted to raise above a desired maximum (usually in the neighborhood of 130 F) unsatisfactory results may be expected. If the amount of radiating surface in piping and reservoir is high with respect to the amount of the energy going into oil heating, the results will be satisfactory —but there are no average figures that apply to all applications. In general, it is possible to dissipate from one to two horsepower into the oil without encountering excessive temperatures. If the wasted energy is more than this amount, it may be necessary to use a heat exchanger, or to specify a more efficient control.

A control that avoids the waste of power is shown in Fig.2(B). The flow control valve is eliminated and the pump is of the variable delivery type. It can be adjusted by one of several convenient methods to deliver exactly the right amount of oil to produce the desired motor speed. The cost of this control is greater than that shown at (A), but in higher horsepower applications, the saving in input power to the system and the improved degree of control will justify the expense.

The selection of a hydraulic motor and the best method for controlling its speed for application on a constant torque drive is here illustrated. Assume that the following are known or desired conditions:

(1) — 5 hp output at maximum speed
(2) — Torque load is constant
(3) — 600 psi oil pressure.
(4) — Motor speed to be variable from 600 to 1,200 rpm.

Using the control illustrated in Fig. 2(A), 5 hp is required of the motor at 1,200 rpm, then 2.5 hp will be wasted at the flow control valve and may result in objectionable heating of the oil. If the amount of speed change were only from 900 to 1,200 rpm, then only $\frac{1}{4}$ of the maximum, or 1.25 hp, would be wasted and could probably be tolerated.

To determine the displacement of the motor, first find its torque requirement by the use of Eq. (1) as follows:

$$\text{Torque} = \frac{Hp \times 63{,}025}{S} = \frac{5 \times 63{,}025}{1{,}200} = 264 \text{ lb-in.}$$

Next use Eq. (2) as follows:

$$\text{Displacement} = \frac{T \times 100}{600 \times 16} = \frac{264 \times 100}{600 \times 16} = 2.75 \text{ cu. in/rev.}$$

The volume of oil required at 1,200 rpm will then be:

$$\frac{2.75 \times 1{,}200}{231} = 14.3 \text{ gpm}$$

The above computations assume 100 per cent efficiency; it is necessary to apply factors that represent the anticipated efficiency of the equipment.

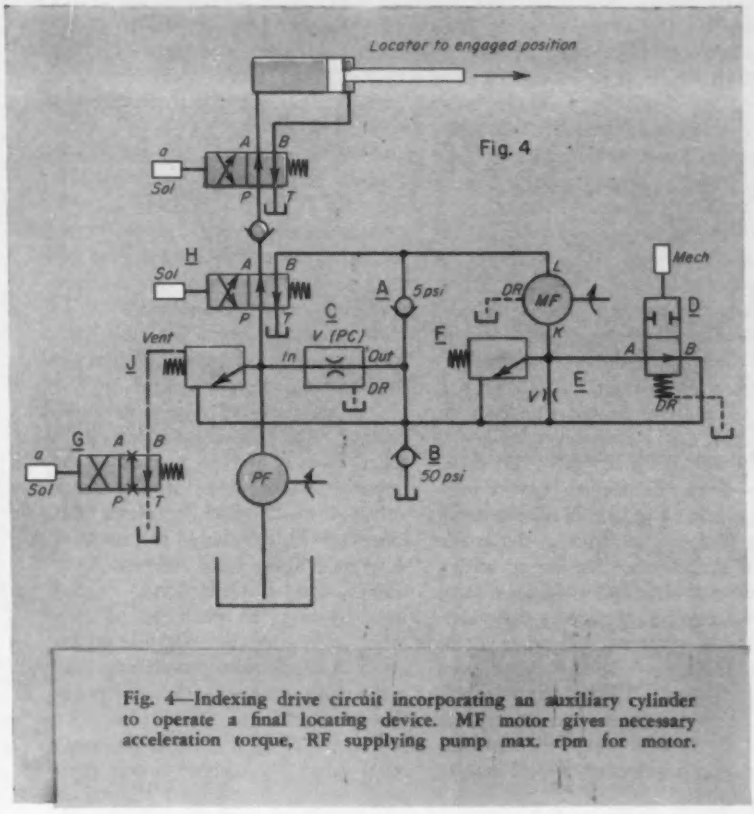


Fig. 4—Indexing drive circuit incorporating an auxiliary cylinder to operate a final locating device. MF motor gives necessary acceleration torque, RF supplying pump max. rpm for motor.

VARIABLE TORQUE REWIND DRIVE. A variable torque hydraulic motor is used extensively to maintain constant tension on winding rolls in textile, plastic, ferrous and nonferrous metal, and other industries. Material coming from the processing machines travels at a constant rate, and if the tension is held uniform, a constant horsepower is represented. If the hydraulic motor is supplied with a constant volume of oil at a constant pressure, a constant horsepower drive must result.

The constant volume of oil is obtained by driving a constant displacement pump from the processing machine so that the pump output is always directly proportional to speed of machine output. The constant pressure is obtained by using a variable displacement motor with a pressure control governing motor displacement. As the material builds up on the spool and the torque requirement increases, the oil pressure will increase. The pressure compensator will then increase motor displacement slightly, thereby restoring the pre-set pressure situation and also reducing the motor speed slightly. This process of gradually increasing the motor displacement proceeds throughout the time the material is building up on the spool—in the usual application over a diameter change ratio of 4:1, and there are means of increasing the 4:1 ratio if necessary. As a general rule, drives involving less than one horsepower are too low in power requirements to respond properly to the control just described. In such instances, the fluid motor control can be changed to one utilizing a direct mechanical or hydraulic servo control. A weighted dancer roll can be used to produce the desired tension on the material, Fig. 3. It is mechanically connected to the displacement control on the variable displacement motor so that as the material builds up on the spool and increases in speed, the dancer roll will rise and change the motor displacement to produce a slower rate of rotation.

INDEXING DRIVE. Modern production practice calls for non-productive machine functions, which include indexing, being accomplished in a minimum amount of time. This means that acceleration must be fast and the maximum rate as high as consistent with reasonable safety. Deceleration must be smooth and quick. On most applications of this type, a fixed displacement hydraulic motor presents a degree of flexibility that makes it ideally suited.

Acceleration rate is determined by the torque capacity of the hydraulic motor and the available oil pressure. An overload relief found in such circuits prevents excessive pressures and minimizes shock during acceleration.

Deceleration, too frequently, is not carefully analyzed. First, it must always be controlled by manipulating the flow of oil leaving the fluid motor —not the oil entering. Otherwise, cavitation with accompanying loss of control and possible damage to the fluid motor and the pump can result. Second, time must be given over to deceleration. The amount of time is determined by the amount of pressure generated by the motor (which functions as a pump and is driven by the kinetic inertia at the load during deceleration) when the outgoing oil flow is restricted. If the pressure is permitted to reach values in excess of the ratings of the motors and valves, shock is to be expected. Instant stopping without shock is impossible.

A typical control, Fig. 4, for an indexing drive illustrates the solutions to some of these problems. The motor is selected to provide adequate torque for acceleration, and proper pumping characteristics during deceleration. The pump is selected to provide required motor speed, while flow through valve *C* determines the amount of speed reduction.

Valve *D*, which controls deceleration, is cam-operated to reduce the rate of flow from the motor. It may be necessary to change the angle of the actuating cam after a trial has revealed the actual amount of pressure that is generated. The valve is depressed until flow through it is terminated.

Needle valve *E* insures a slow flow of oil from the motor after the deceleration valve has been closed completely. The flow can be varied to suit the job, but when the solenoid of the control valve is de-energized, the motor should stop instantly.

The solenoid of the four-way valve *H* is energized to start rotation and is finally de-energized to stop.

Check valve *B* provides an adequate

amount of low pressure oil through check valve *A* to prevent cavitation at the input of the motor at the final stop. If the stop should be sudden, this cavitation could be serious.

Relief valve *F* should never open. If the motor size and the cam angle have been suitably selected, deceleration pressures will not reach relief pressure. However, if the indexing load is improperly increased, the relief valve serves as a protective device. If it should open during deceleration, accurate control of the motor will be lost.

Valve *G* is a small solenoid valve controlling the vent port of the balanced piston-type relief valve *J*. The solenoid is energized whenever the full set pressure is required for operation. After indexing is complete and the locator in place, the solenoid may be de-energized and the setting of *J* will drop to venting pressure—sufficient to hold the locator in place but not enough to cause heating of the oil.

BRAKE CONTROL. In many applications, deceleration of a hydraulic motor is required, not by a distance control of a load being moved as in indexing, but by a torque resistance applied to the motor rotation. This resistance can be applied in what is frequently called a brake control. The circuit shown in Fig. 5 utilizes brake control for both directions of motor rotation. It also includes the use of an open-center four-way valve to control direction of rotation.

When the solenoid of the four-way valve is energized, oil from the pump is available at port *A*. The resulting pressure through line *E* holds valve *D* open. Thus, there is no resistance to oil leaving the motor at port N.

When the solenoid is de-energized the pump delivery escapes through the tank port of the four-way valve and is insufficient to hold valve *D* open. Valve *D* can be opened only by pressure generated at port *N* off the motor by a kinetic load forcing the motor to act as a pump. The spring setting on valve *D* determines the amount of resistance to be supplied by that valve.

Valve *C* controls deceleration in the opposite direction, and can be adjusted independently. When both solenoids are de-energized, the pump delivery flows out the tank port to the reservoir. The pump is unloaded and oil heating is avoided.

Valve *F* creates a light back pressure to insure positive pressure at the motor inlet during deceleration. This back pressure prevents cavitation and permits pilot operation of the four-way control valves.

Another braking circuit, which also controls both directions of rotation, is shown in Fig. 6. This circuit, however, utilizes a closed-center four-way valve so that the pump delivery is available for use elsewhere when not required for operation of the fluid motor.

When either solenoid of the four-way valve is de-energized, the oil leaving the motor encounters the blocked port of the four-way valve at its center position. The resulting pressure causes relief valve *A* or *B* to pass oil to the opposite motor line through check valves *C* or *D*. Each relief valve is independently adjustable to provide a different braking value for each direction of rotation. Cavitation is avoided by delivering the discharge of each relief valve into the opposite motor line and in addition, pressurizing both motor lines with oil from the pump through line *E*.

Valve *F* is used to vent the main relief valve. Its solenoid is kept energized during the pressure interval in each branch of the circuit.

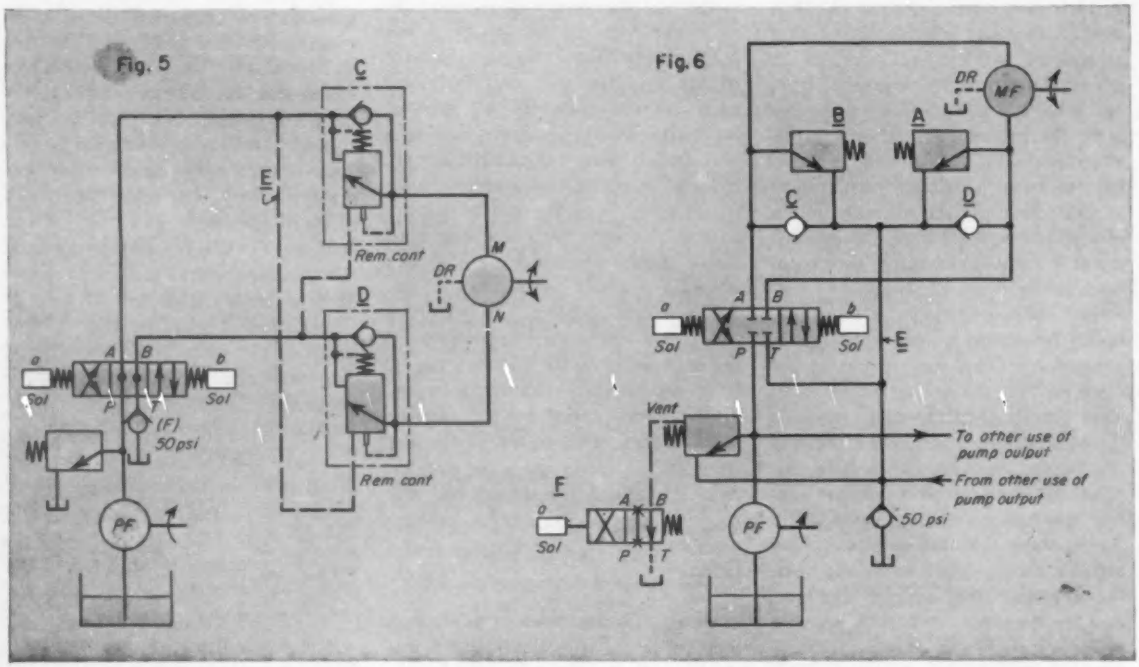


Fig. 5—Circuit providing brake control in both directions of rotation. The open-center four way valve controls direction of rotation. Positive motor inlet pressure controls cavitation.

Fig. 6—Another type of hydraulic motor braking control, this one utilizing a closed center valve so that pump output can be used for other purposes than to power the motor.

Paint Specifications For Metal Products

Recommended finish formulations and application procedures for eight major classes of industrial products. Included is specific information connecting properties and composition.

PAUL E. MARLING
Consultant

Table I—Selecting Resins on the Basis of Properties Imparted to the Finish

Properties	Resins Having Desirable Qualities	Resins Having Poorer Qualities
Color retention	Silicone, Alkyd-amine, Alkyd, Acrylate	Vinyl, Phenolic
Fast drying (Air)	Nitrocellulose, Styrenated alkyd	Alkyd-amine, Silicone-alkyd
Drying (Bake)	Alkyd-amine, Silicone-alkyd, Acrylate	Cellulosic, Silicone
Acid, alkali, and water resistance	Vinyl, Phenolic, Acrylate, Epon	Alkyd, Rosin ester
Adhesion	Alkyd, Phenolic, Epon	Cellulosic, Vinyl
Flexibility	Alkyd, Acrylic, Epon	Styrenated alkyd, Vinyl
Hardness	Alkyd, Alkyd-amine, Phenolic	Chlorinated rubber, Silicone
Heat resistance	Silicone, Silicone-alkyd Acrylate, Alkyd	Vinyl, Chlorinated-rubber
Outdoor durability	Alkyd, Phenolic, Silicone, Vinyl	Hydrocarbon, Rosin ester
Salt spray resistance	Phenolic, Silicone, Acrylate	Hydrocarbon, Rosin ester
Abrasion resistance	Alkyd-amine, Phenolic	Styrenated alkyd, Silicone

WITH THE ADVENT of innumerable new synthetic finishing resins that can be used alone, in combination with one another, or in combination with established materials, the problem of selecting a finish for a metal product has become infinitely complex. Especially is this true since most industrial coatings must be custom formulated to meet the peculiar requirements for each product. The objective is a finish that will provide the ultimate in appearance and will protect the surface for varying periods of time and under a wide range of atmospheric and climatic conditions.

Important primary properties can be formulated into these coatings—usually by sacrificing some of the secondary values. But there is no one "best" all-purpose finish. Each type has its good qualities and limitations. Both vehicle and pigment play an important part in the coating. The vehicle, regardless of its chemical composition, must be able to be changed from a mobile fluid state to an immobile solid state. The resin selected for the vehicle, Table I, greatly influences properties. The pigment portion which acts as an armor, should possess opacity, hiding power, enduring color and ability to blend with the vehicle as some of the chief characteristics. The volatile thinner can be designed

to accelerate spreading and aid adhesion of the film. The driers can be selected not only to accelerate drying but to add hardness.

Since the designer or engineer may or may not be an expert in this field—chances being that he is not—some specific information is needed that connects the properties of the film with the specification for the composition and outlines general procedures that meet commercial conditions in producing a good finish.

Metal Preparation—The loss of decorative appearance and early failure of many coatings can be traced to lack of care in insuring a clean surface for painting. Rust, oils, moisture, grease and dirt have a harmful effect on paint adherence.

Proper surface preparation includes cleaning and sometimes chemical treatment. The removal of foreign materials such as rust, oil and dirt may be accomplished by solvent degreasing, alkali washing, acid treatment, or wire brushing.

Chemical treatment of the cleaned metal is the next step for products that have to withstand high humidity or excess moisture conditions in service. Phosphatizing, chromatizing or other chemical treatments may be used. The success of the chemical treatment as a base for paint coatings is due to the formation of surface films that not only are uniform and strongly adherent to the base metal but inhibit rusting. Such treatments may be applied by spraying or dipping the metal parts.

The next step is the drying of the metal, usually through low temperature ovens, infra-red heat, or by wiping to remove all traces of moisture.

Coating Application. Benefits resulting from cleaning operations and selection of the paint may be lost unless the paint is applied properly and under appropriate conditions. Proper application involves the selection of a suitable painting method and skill in using that method. Industrial finishes are usually applied by spray, dip, roller coat, tumbling or electrostatic spraying. Spray painting is normally used for most industrial products and can be adapted to any type of finish.

Dipping is the next most popular method; it is best adapted to small objects that have a uniform shape. "Tear drop" at point of draining may be objectionable. Products with a uniform cross-section such as wire can be passed through a flexible collar to remove the excess paint.

Roller coating is used for flat sheets. Tumbling is used for buttons and similar shaped products. Electrostatic spraying as the products pass through an electric field is

I—FINISHING SYSTEMS FOR AUTOMOBILES AND TRUCKS

The film properties required for these products include excellent outdoor durability, good color and gloss retention, good cleaning and polishing properties, good abrasion and mar resistance, good gasoline, oil, grease, stain and water resistance, and good adhesion.

The metal is cleaned, treated with a phosphate coating, rinsed, dried, and sprayed with one coat of primer. The primer vehicle is of the alkyd, phenolic, or oleoresinous type; has not under 40 percent non-volatile content. The primer normally contains from 40 to 45 percent pigment, consisting of $Fe_2 O_3$ not under 50 percent; zinc chromate not under 10 percent, and siliceous extenders not under 30 percent. This coating will withstand one year exposure to weather with only slight dulling, and will not dull after gasoline immersion for one-half hour followed by a four hour recovery. If air dried, it will set to touch within ½ to 2 hr, and dry in about 18 hr. It will bake hard in approximately one hour at 250 F, and in about one-half hour at 300 Fahrenheit.

A surfacer is applied over the primer. The vehicle and pigment composition of the surfacer are the same as in the primer, except that more pigment is used to improve sanding and hold-out properties, and inhibitive pigments may be omitted. The pigment should be not less than 50 percent, and, in addition, the vehicle should contain not under 25 percent non-volatile. The surfacer usually is spray coated, and baked for one hour at 250 F. It may be hand or machine sanded, using water wet No. 325 sandpaper.

The oleoresinous type varnish mentioned for the primer

or primer-surface vehicles above and in several other groups contains combinations of dehydrated castor, linseed, soya, oiticica, and/or tung oils processed at 450 to 525 F with resins such as rosin ester, maleic ester, hydrocarbon, coumarone-indene, or others. The phenolic type contains oil soluble phenol-formaldehyde resins processed at 425 to 475 F with a combination of linseed and tung oils.

The alkyd type contains a polyhydric alcohol such as glycerine or pentaerythritol, a polybasic anhydride such as phthalic anhydride, and oils such as soya, safflower or linseed. These ingredients are reacted by processing at 450 to 500 Fahrenheit.

All three types require driers for air drying. The phenolic type is the fastest drying.

Top coat finish may be a nitrocellulose lacquer enamel or a synthetic resin enamel.

Nitrocellulose Lacquer Enamel. The vehicle normally con-

very effective for coating irregularly-shaped products.

The number of coats and the after treatment of each coat are usually dependent on the kind of product and the type of finish. The primer or first coat is designed for adhesion to the metal. Both vehicle and pigment should be specifically selected from compositions of known past performance. The primer may be baked or air dried.

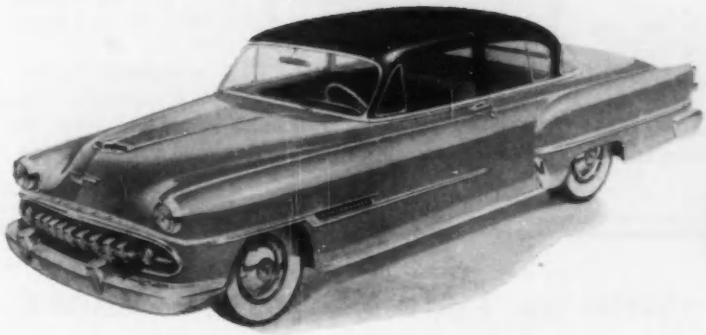
In some cases where a smooth surface is required, a surfacer is applied over the primer. The amount of pigment in a surfacer is higher than in a primer, and it contains components that sand readily after drying. The use of a composition product known as a primer-surfacer will give results with one coat. Inhibiting pigments such as zinc cromate or red lead are often used in primer or primer surfacer coatings to protect metal from corrosion in high humidity areas. The general characteristics required in primer, surfacer, and primer-surfacer base coats are adhesion, hardness, toughness, hiding power, holdout, sanding and good drying properties.

Curing. Ovens are used where any degree of heat is involved. They vary widely in temperature range. Gas, electricity, steam and oil can be used as heat sources. Gas may be used as open flame, to produce infra-red heat by means of a refractory, or to supply heat to a heat-exchanger that in turn heats circulating air. Electricity may be used to supply power to infra-red heat lamps or resistance coils or heating elements.

The temperature depends on the drying properties of the finish and the space and time available for the drying process. Method of curing will be indicated in the product groups discussed below by air drying or baking. Air drying includes drying by solvent evaporation, as in lacquers; and oxidation plus polymerization, as in alkyd resins. Baking includes solvent evaporation, oxidation and/or polymerization.

An idea of the effectiveness of these methods can be obtained by comparing the time required to dry an alkyd resin. If dried in air at 75 F, the resin will set to touch in 2 to 4 hr, and be hard within 18 to 24 hr. Baked at 250 F in an oven, the finish will dry in about one hour; at 300 F it will dry within approximately one-half hour in an oven or about 10 min under infra-red.

The selection of the coatings for metal products is discussed in the following sections in relation to the type of finish for producing desirable film properties. The eight groups of finishing systems overlap in some primary and secondary properties, but provide a general plan that may be applied to a particular situation.



tains one part, ½ sec nitrocellulose; one part, non-to semi-oxidizing short oil alkyd (40 to 45 percent phthalic anhydride) plus 10 to 40 percent urea formaldehyde or melamine formaldehyde resin; and one-third part plasticizer-dioctyl phthalate and castor oil; non-volatile, 20 to 30 percent. The pigment should be suitable for color, brilliance, texture, tinting strength, color permanency, hiding power, and opacity. No benzol or chlorinated types of solvents should be used.

Usually application procedure is to spray two double coats of this lacquer enamel, the first double coat being baked for one-half hour at 150 to 180 F and the second coats being baked for one-half hour at 150 to 180 F. If air died it is set to touch in one-half to one hour. The finish is polished to a high gloss with a wool disk, using wax plus a fine abrasive.

This finish is resistant to gasoline, water spot, grease, oil, stains, and cold check (one hour exposure at 0 F followed by one hour at 120 F). Hardness is 18 to 20 percent (Sward). There is only slight dulling after one year exposure to weather, after which the coating will polish to a good gloss.

Synthetic Resin Enamel. The vehicle in this enamel consists of medium length oil alkyd resin (30 to 40 percent phthalic anhydride), with or without 10 to 30 percent urea or melamine formaldehyde resin; non-volatile materials range up to 40 to 50 percent.

The air drying type (without amine but with a drier) sets to touch within 2 to 4 hr, and is hard within 18 to 24 hours. The combination of alkyd and amine resins will not air dry, and driers will not help.

As with the lacquer enamel, the pigment should be suitable for color, brilliance, texture, tinting, strength, color permanency, hiding power, and opacity; and no benzol or chlorinated solvents should be used in the thinner.

Usually these synthetic resin enamels are applied in two coats three to five minutes apart and oven baked for one hour at 250 F. They may be used over a primer coat or a combination primer-surfacer coat if the metal surface is smooth to give the desired end result.

II—FINISHING SYSTEMS FOR AIR COMPRESSORS, CONSTRUCTION EQUIPMENT, CRANES, HOISTS, AND FORK LIFT TRUCKS

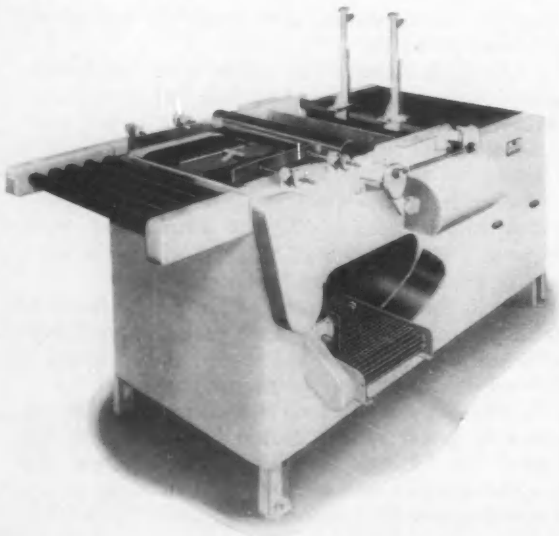
The film properties required for equipment of this type are good outside durability, good adhesion, high hardness, excellent abrasion and mar resistance, and good gasoline and water resistance.

Metal preparation includes cleaning, phosphatizing, rinsing, and drying—although the phosphate treatment may be omitted if adhesion can be sacrificed somewhat. This is usually followed by a spray coat of primer-surfacer, the vehicle of which is of the oleoresinous, phenolic, or alkyd type, with non-volatile materials not under 40 percent. From 45 to 50 percent pigment, consisting of 5 to 20 percent inhibitors and extenders with good sanding and holdout properties, is present.

This primer-surfacer will set to touch in air in one to two hours and dry hard in 18 hrs; baking requires one hour at 250 F. Before application of the top coat, the surfacer is sanded under light pressure with wet No. 325 sand paper, and dried.

The top finish coating may be a nitrocellulose lacquer enamel or a synthetic resin enamel, as outlined under Group I, or an oleoresinous enamel. The vehicle for this latter type contains linseed oil, dehydrated castor oil,

III—FINISHING SYSTEMS FOR FARM EQUIPMENT, PACKAGING



Good outside durability, good color and gloss retention, good adhesion and hardness, good solvent, water and stain resistance, and fair alkali resistance are the most important properties required in a finish for products in this group.

A primer-surfacer is applied after the metal is cleaned, washed, and dried. The vehicle may contain alkyd, phenolic, or oleoresinous varnish, with not under 40 percent non-volatile materials. It also contains from 45 to 50 percent pigment containing not more than 30 percent extenders.

A single sprayed coat, baked for one hour at 250 F, or air dried (set in one to two hours, hardened in 18 hours) suffices for all applications. It is sanded under light pressure with wet No. 325 sandpaper, and dried.

The top finish coat may be an oleoresinous enamel (see Group II) or a styrenated alkyd resin enamel. The vehicle for this latter finish contains a copolymer of alkyd resin and monostyrene, and a minimum of 29 percent non-volatile materials consisting of 18 to 26 percent phthalic anhydride.

If dried in air, this enamel is set to touch in about 10

oiticica oil, tung oil combinations, with rosin ester, maleic resinate, hydrocarbon resins, and suitable pigments having satisfactory color, texture, tinting strength and color permanency.

This oleoresinous enamel, however, may be sprayed either in one or two coats, and baked for one hour at 250 F or for one-half at 300 F. If air dried, it will set to touch in 2 to 4 hr, and harden within 18 hours. The enamel can be stored for a minimum of 60 days without change.

Two coats of finish will add value to all properties of the dried film. The oleoresinous varnish is processed at a temperature of 450 to 525 F for a time necessary to produce satisfactory viscosity. Driers are required for air drying. Wrinkled finishes may be prepared when sufficient tung oil is used in processing the oleoresinous varnish; excess cobalt drier is needed. Wrinkle finishes may be clear or pigmented, sprayed wet to a film thickness of 4 mils, and baked from 15 to 30 minutes at 300 to 375 F. They may be used without the primer-surfacer; however, a mist coat of primer will improve the adhesion.

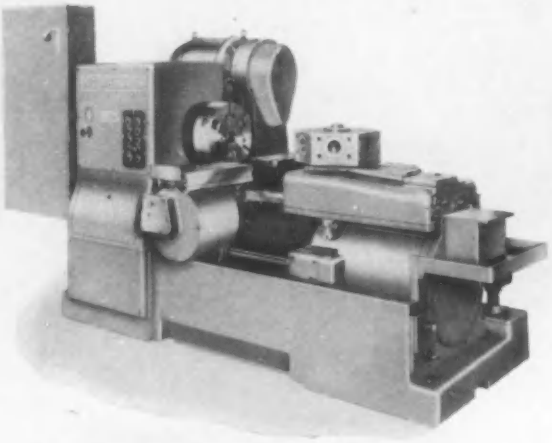
MACHINERY, AND HARDWARE

minutes, and is fairly hard within 30 minutes. It can be recoated after a 24 hr air dry, or after being baked for 15 min. at 220 F. Normally a single spray coat is satisfactory; it is air dried for from one-quarter to one-half hour, or baked 5 to 10 minutes at 220 Fahrenheit.

Three coats of this finish in the clear condition will withstand 10 months exposure to weather without film deterioration. Pigments having suitable color, texture, tinting, strength, and color permanency can be added to the vehicle. Storage stability is indicated by no change in 30 days, providing the solids content is not under 50 percent.

This styrenated alkyd resin enamel can be produced in a gloss or hammered finish. Hammered effects are obtained by spraying a single coat in a poorly atomized state, and are cured by baking at 300 F for 5 to 10 minutes. Such finishes are excellent for covering minor imperfections, and therefore are popular for rough surfaces. Light tints are best. Adhesion on bare rough metal is excellent if the finish is baked for 15 min. at 300 Fahrenheit.

IV—FINISHING SYSTEMS FOR MACHINE TOOLS



Salient requirements for a finish for machine tools and castings are good abrasion and mar resistance, good gasoline and oil resistance, and good adhesion.

Metal preparation includes snagging and grinding, solvent degreasing, and drying. The next step is the application of a filler to close the pores in the surface of the metal. Common practice is to specify a pigmented phenolic or polyester resin, or nitrocellulose lacquer.

Phenolic type fillers contain solvents that are difficult to remove from the pores and may cause strains; they are cured by heat at 300 to 350 F, and are thermosetting. Polyester fillers, which are 100 percent non-volatile, can usually be used with better results. They contain a thermosetting resin—glycol, maleic, phthalic, styrene—are catalyzed by peroxides, and are cured at 300 Fahrenheit.

V—FINISHING SYSTEMS FOR REFRIGERATORS, VACUUM

Desirable film properties for these articles are excellent color retention, good abrasion and mar resistance, good adhesion, and resistance to chemicals, vegetable oil, food stains, and alkali.

After degreasing, cleaning, and drying of the metal, a primer-surfacer coating is applied. The vehicle may be an alkyd, phenolic, or oleoresinous type containing not under 40 percent non-volatile material. The pigment is chosen for suitable color, texture, and color permanency.

A single mist or full coat of this primer-surfacer is sprayed on, after which it is baked for 10 to 15 min. at 300 F; if dried in air, it hardens within 24 hours. Final operation before application of the top finish coat is a light dry sanding operation with No. 325 sandpaper, followed by dusting with "tack rag."

VI—FINISHING SYSTEMS FOR OFFICE EQUIPMENT AND FURNITURE, PHOTOGRAPH EQUIPMENT, TV AND RADIO CABINETS, CASH

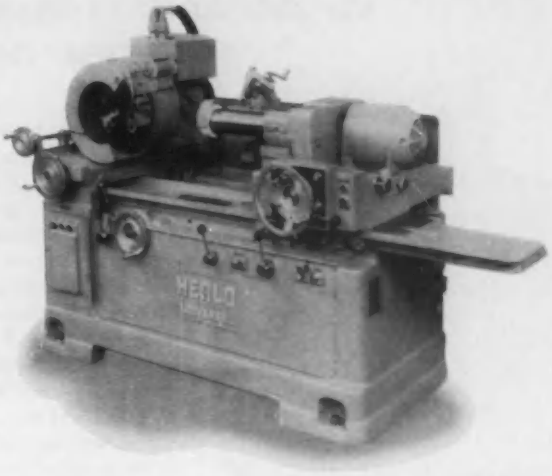
For such equipment as covered in this group, abrasion and mar resistance, good adhesion and impact strength, good stain, sweat and moisture resistance, and good solvent and chemical resistance are required of the finish.

Initial steps in the process are metal degreasing, cleaning, and drying; and application of a mist coat of primer-surfacer having the same composition as the formulation described in the previous section. This coating is baked for one hour at 250 F, given a light scuffing treatment with dry No. 325 sandpaper, and rubbed with "tack rag."

Anyone of several top coat finishes can be used as follows, depending on the product, type of service, and desired appearance:

1. Oleoresinous varnish enamel as outlined for Group II. This may be applied to produce a gloss, hammered, or wrinkled finish.

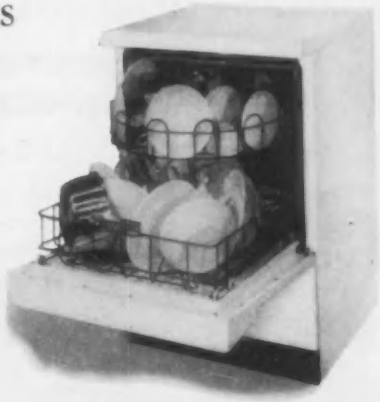
AND CASTINGS



Hot spraying can be used with the nitrocellulose lacquer, which is advantageous since it permits a greater concentration of solids, and therefore greater coverage per coat. Also, it dries in air, whereas the other fillers must be exposed to elevated temperatures. Since most large castings cannot be placed in an oven, phenolic or polyester fillers often are cured with a torch; in this case, a component that produces a color change at the desired curing temperature can be added.

After sanding down the filler with wet sandpaper, drying, and "tack rag", one coat of sealer, consisting of a pigmented nitrocellulose lacquer, is sprayed on the surface and air dried for from one-half to one hour. The same procedure is followed with the finish coat—also, a pigmented nitrocellulose lacquer.

CLEANERS AND OTHER HOUSEHOLD APPLIANCES



The finishing coat is a synthetic resin baking enamel. The vehicle for this enamel consists of short soya, cottonseed or castor oil alkyd resin; 40 to 42 percent phthalic anhydride, 34 to 38 percent oils plus melamine or urea formaldehyde resin, alkyd to amine ratio being three parts to two. A titanium dioxide (rutile) is used as a pigment.

Pigment to binder ratio of the enamel is 75 to 100 by weight. Storage stability is 60 days without change. Either one or two coats of this enamel are sprayed on the surface and baked from 15 to 30 min. at 275 to 300 Fahrenheit.

Nitrocellulose lacquer enamel as outlined in Group I would be a second choice for a top coat finish. As with the synthetic enamel described above, a titanium dioxide (rutile) pigment should be used to insure color permanency.

BUSINESS MACHINES, PRINTING PRESSES, RECORDERS, REGISTERS, FOOD MIXERS, FANS, AND SIMILAR PRODUCTS

2. Nitrocellulose lacquer enamel as discussed for Group I. This can be used as a high gloss finish, or modified to obtain a cracked or spattered finish.

3. Vinyl modified alkyd enamel. The vehicle for this enamel consists of a copolymer of vinyl acetate and chloride plus miscible alkyd or plasticizer. The pigment is chosen for texture, opacity, and color permanency.

4. Synthetic resin enamel, as outlined for Group I.

A few words should be said about the specialty finishes mentioned above. Wrinkle finishes, which are obtained with tung oil type oleoresinous varnish enamels, are excellent for rough metal or to cover surface defects. They are sprayed to a wet film thickness of about 4 mils, placed in a zoned oven held at 250 to 275 F, and baked at 300 to 375 F for from 15 to 30 minutes. If initially placed in the oven at 300 to 325 F, the film may not wrinkle. Various designs can be produced successfully by a skilled spray operator.

Spatter finishes are produced with nitrocellulose lacquer enamel. A colored undercoat is first applied, and air dried. A second contrasting color is then spattered over the first.

Crackle finishes also are produced with nitrocellulose lacquer enamel. A fast drying coat is sprayed over a slow drying type; both are air dried.

Hammered finishes, as mentioned in Group III, also are used, as is silk screen printing of lacquer finishes, and graining. However, a hammered finish is obtained with an oleoresinous varnish enamel by a two coat system—a solvent spray is spattered in droplets or mist over a wet undercoat. The same effect can be obtained by simultaneously spraying the solvent and the enamel through the same gun. The coating, which is baked for 5 to 10 min. at 300 F has good gloss. Light colors are best.

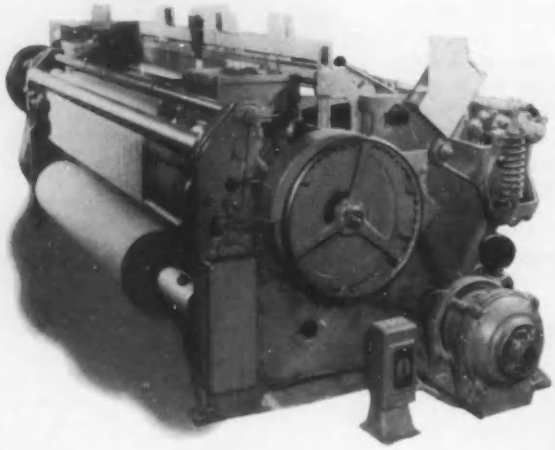
VII—FINISHING SYSTEMS FOR STOVES, FURNACES, MOTORS, MOTOR HOUSINGS, MOTOR CYCLE CYLINDERS,

Properties required in the finish are high temperature resistance, good adhesion, abrasion and mar resistance, good stain and chemical resistance, and high hardness.

Included in metal preparation are degreasing, phosphatizing, and drying operations. A primer-surfacer coating is then applied. It may be either one of two types: (1) an alkyd or oleoresinous vehicle; or (2) an epon resin vehicle modified with drying oil fatty acid. A mist or light coat of the primer-surfacer is sprayed on, baked for one hour at 250 F, and given a light scuffing treatment.

Several types of enamels can be used as the finish coat. A synthetic resin baking enamel is perhaps the most economical, but not as resistant to temperatures above 500 F as other types that are available. The vehicle for this consists of a short oil non-drying type alkyd with 40 to 45 percent phthalic anhydride containing pentaerythritol, and a melamine or urea formaldehyde resin. Alkyd to amine solids ratio should be approximately 70 to 30 parts, and non-volatile materials should be not under 50 percent. A titanium dioxide (anatase) and

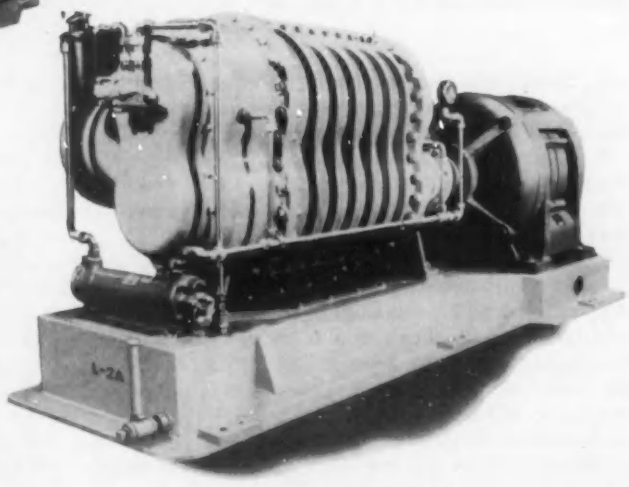
VIII—FINISHING SYSTEMS FOR CHEMICAL EQUIPMENT, HYDRAULIC DISPENSING MACHINES, OIL TANKS, MARINE WINCHES,



Finishes for products in this group should be resistant to weak acids and alkalis, chemicals, stains, gasoline, oils, grease, water, and high humidity; have good abrasion and mar resistance; and have good adhesion and high hardness.

The finishing operation starts with degreasing, phosphatizing, washing, and drying of the metal. The primer-surfacer coating sprayed on as a mist or light coat consists of 10 to 30 percent inhibiting type pigment such as zinc chromate or red lead, and an alkyd, phenolic, or oleoresinous vehicle. This coating usually is baked for about one hour at 250 F, and given a light scuffing operation with wet or dry No. 325 sandpaper.

The top finish coat that then is applied may be (1) a



LABORATORY OVENS, EXHAUST PIPES, BRAKE DRUMS, SUN LAMPS, RADIATOR COVERS, GASOLINE PUMPS

suitable colored pigment having permanency of color after exposure to heat is recommended.

This enamel is applied as a single coat, and baked 10 to 20 min. at 300 to 325 Fahrenheit. It can be stored for 60 days without change.

Another, and more heat resistant enamel is a modified silicone alkyd enamel pigmented with titanium dioxide (anatase), aluminum powder, carbon black, heat-resisting phthalocyamine blues or greens, or red iron oxide. Storage stability is 60 days without change.

A single spray coat, baked 15 to 45 min. at 300 F or 15 min. at 350 F, usually is satisfactory. It has good adhesion if applied directly over a phosphatized surface. Heating tests at 575 F for 24 hr indicate no change in a clear vehicle.

The third finish used for products in this category is a modified acrylic enamel. The vehicle consists of an acrylic resin and a chlorinated diphenyl; the pigment is the same as used for modified silicone enamel, which is sprayed or dipped.

PUMPS, OIL DRILLING EQUIPMENT, TEXTILE MACHINERY, REFINERY EQUIPMENT, GASOLINE PUMPS, WELDING EQUIPMENT

vinyl modified enamel; (2) a chlorinated rubber modified enamel; (3) an epon modified enamel; (4) a synthetic baking enamel as outlined in Group VII.

Details are as follows:

Vinyl Modified Enamel. Vehicle is a copolymer of vinyl acetate and chloride, a plasticizer, and an inhibitor for preventing color change. The pigment is selected for suitable texture, opacity, and color permanency. Storage stability of the enamel is good; it will withstand storage for a minimum of 60 days without change, as will the other enamels listed below. It is sprayed either in one or two coats, and baked for about one hour at 250 Fahrenheit.

Chlorinated Rubber Modified Enamel. The vehicle in this finish is chlorinated rubber plus a plasticizer. The pigment is selected for texture, opacity, and color permanency. Either one or two coats are sprayed on the product, and baked for one hour at 250 Fahrenheit.

Epon Modified Enamel. These enamels may be applied directly over a phosphatized surface instead of over a primer-surfacer. The vehicle consists of epon resins plus amines or fatty acids. Epon is processed with drying oil fatty acids at temperature of 450 to 500 F for reaction.

This enamel also is sprayed on. Either a single or double coat can be used. It is baked at 250 F for one hour.

AREAS FOR IMPROVEMENT

So many specific coatings on such a variety of products are being produced today, that it is impossible to discuss them all. However, several practical types have been suggested in limited detail. Contacts with producers of finishes are important to the designer, as most manufacturers of finishes have competent chemists and chemical engineers who have a wide background in raw materials, finishes and best methods of application.

Some producers of coatings have established a system of rating by which a certain number of points are assigned to each property. Since only two or three outstanding properties usually are required in any given coating, such a system could be used by the designer in classifying all available finishes.

All trends point to the appearance of the product as important in selling. But in recent years more attention has been given to appearance after a period of time in service. It is from this standpoint that many finishing systems could be profitably redesigned.

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Note: The illustrations used in this article do not necessarily show products that are painted by the same procedures or with the same vehicle formulations described in the text. They were selected only as representative products.

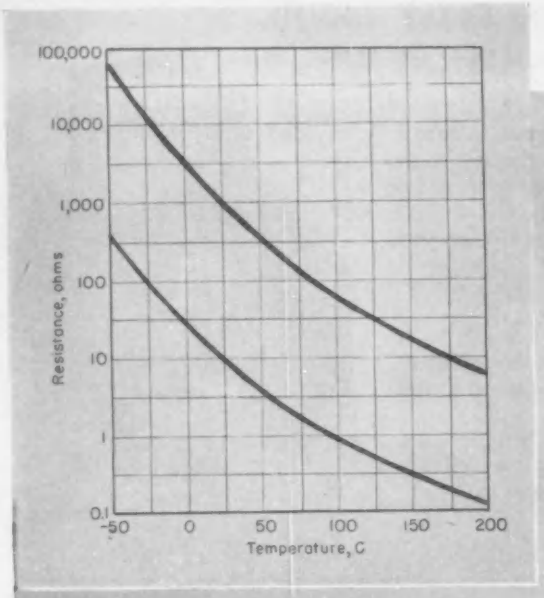


Fig. 1—Resistance versus temperature curves for two typical thermistors. Principal characteristic of thermistors is a large negative temperature coefficient as shown by the negative slope of the curves.

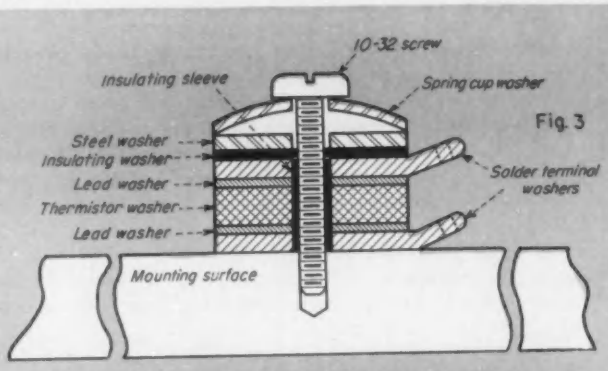
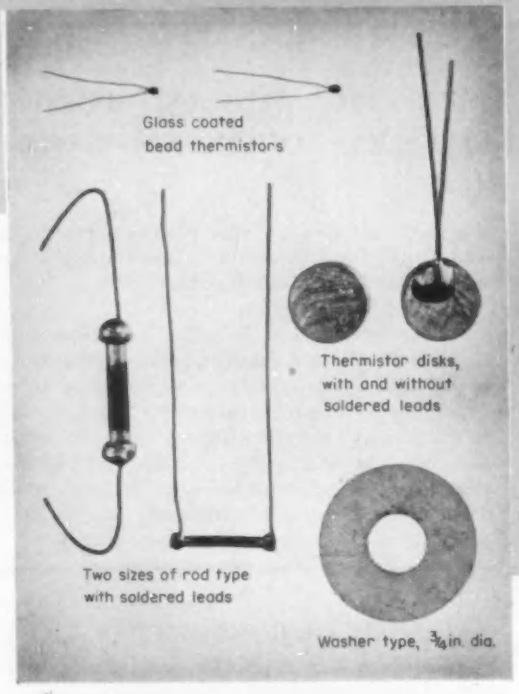


Fig. 2—Various types of commercially available thermistors.


Glass coated bead thermistors
Thermistor disks, with and without soldered leads
Two sizes of rod type with soldered leads
Washer type, 3/4 in. dia.

Which Type Thermistor?

FRANK K. BENNETT
Director of Research and Development
Victory Engineering Corp.

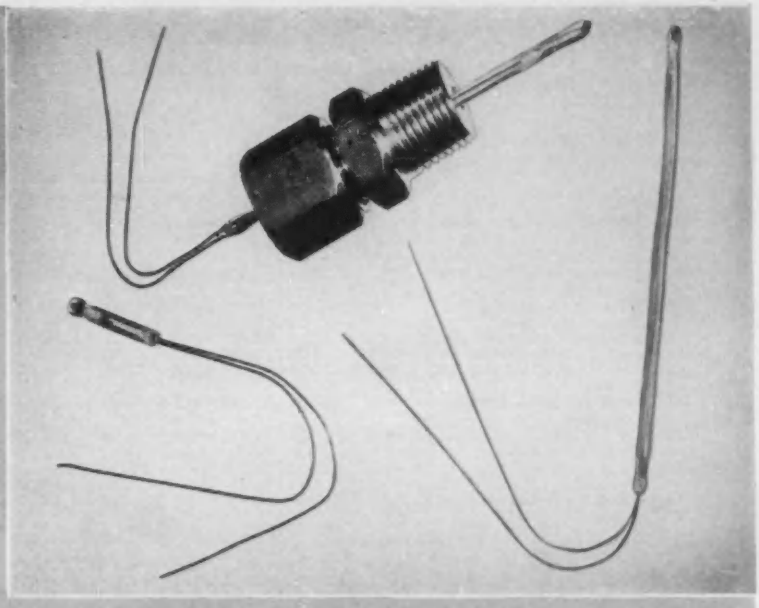
THERMISTORS are thermally sensitive resistors that exhibit a resistance change of about 4 percent per degree Centigrade. They have a stable, ceramic-like structure consisting mostly of metallic oxides, and are commercially available in a variety of shapes such as disks, washers, rods and beads. The high temperature coefficient of thermistors, about ten times that of typical metals, makes these devices useful for temperature control, temperature measurement and temperature compensation. Other less common applications include electrical time-delay or surge suppression, volume limiting and regulation in communication circuits, and microwave power measurement.

The temperature coefficient of a thermistor is negative; that is, the resistance of a thermistor decreases as temperature increases, Fig. 1. Roughly, a thermistor doubles its resistance for every 20 C decrease in temperature. The room-temperature resistance of a given thermistor can vary from a few ohms for the lowest resistance disk or washer type, to several megohms for the highest resistance rod or bead type.

These units have good long term resistance stability. After suitable pre-

Fig. 3—(Left) Typical mounting arrangement for ¼ in. diameter thermistor washer. Lead washers protect thermistor wafer from damage when screw is tightened. Assembly is usually bolted to object whose temperature is being measured.

Fig. 4—Glass probe with bead-type thermistor sealed in end of glass rod. Packing gland can be used where sealing is required, as in fluid temperature measurement. While the glass coated thermistor has a faster response time than the probe shown in Fig. 5, it must be handled more carefully than the metal-well type.



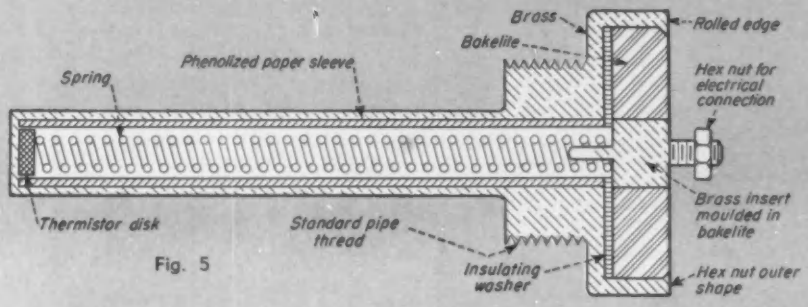


Fig. 5

Fig. 5—Temperature probe assembly using disc type thermistor as a sensing element. This arrangement is normally used to measure fluid temperature where the thermistor must be protected and sealing is necessary. The brass well is one electrical contact and the spring to the center brass insert the other.

First of two articles. Included are basic properties, types and mounting arrangements, and selection factors. Application data will be featured in the April issue.

aging treatment by the manufacturer, typical units have been used at temperatures above 100 C for several years without changing their calibration by as much as 0.1 C. One helpful property is that the aging rate at elevated temperatures decreases with use. Thus a thermistor becomes better the longer it is used. This is in contrast to the behavior of base-metal thermocouples, whose aging rate at elevated temperatures generally increases with use.

TYPES AND MOUNTINGS

Typical samples of the principal types of thermistors are shown in Fig. 2. The disk type is furnished with or without soldered leads. With leads, disks can be soldered into a circuit in the same manner as conventional resistors. Using this mounting arrangement the thermistor senses the surrounding air temperature. Disks without leads are furnished with the flat faces of the disk metallized to serve as the electrical contacts. Such disks can be held between spring contacts, or clamped to an object whose temperature is to be sensed. The disk can also be mounted in a probe assembly, Fig. 5. This is similar in appearance to a standard resistance

Table I—Characteristics of Typical Thermistors

Code No., Victory Eng. Co.	Description	Temperature coefficient of resistance at 0 C, percent per degree	Cold resistance, R_o, ohms			Maximum continuous ambient temperature, C	Maximum current or power, a-c or d-c[1]	Dissipation constant, milliwatts per degree C[2]	Thermal time constant, sec[3]	R_o (0 C) / R_o (50 C)[4]
			at 0 C approx.	at 25 C	at 50 C approx.					
Rods and Disks With Leads or Mountings										
03X1	Bolted pileup of 4 washers connected in parallel	−4.6	7	2.5 ±10%	1.0	150	7 amp	30	300	6.95 ±4.5%
21E2	0.4 in. dia disk; radial leads	−4.6	283	100 ±10%	40.7	125	400 ma	8	140	6.95 ±4.5%
27D1	Disk on tinned brass plate, protective finish	−5.2	2,350	725 ±5%	260	100	140 ma	20	50	9.1 ±3%
28D1	Disk on tinned brass plate, protective finish	−5.2	2,500	760 ±5%	275	100	140 ma	20	50	9.1 ±3%
31D3	0.4 in. dia disk; radial leads	−5.2	3,270	1,000 ±10%	360	125	150 ma	8	140	9.1 ±3%
31D4	0.2 in. dia disk; axial leads.	−5.2	3,270	1,000 ±10%	360	125	130 ma	8	20	9.1 ±3%
33S1	0.11 x 13/16 in. rod; axial leads	−4.6	9,000	3,150 ±10%	1,270	150	75 ma	4	70	7.1 ±4.5%
41S1	0.11 x 1-5/8 in. rod; axial leads	−4.6	28,500	10,000 ±10%	4,000	150	50 ma	6	95	7.1 ±4.5%
43R1	0.11 x 13/16 in. rod; axial leads	−5.2	103,000	31,500 ±10%	11,300	150	30 ma	4	70	9.1 ±3%
51R1	0.11 x 1-5/8 in. rod; axial leads	−5.2	327,000	100,000 ±10%	36,000	150	20 ma	6	95	9.1 ±3%
51R2	0.055 x 1/2 in. rod; radial leads	−5.2	327,000	100,000 ±10%	36,000	150	13 ma	2.5	20	9.1 ±3%
Disks and Washers (Unmounted)										
11X1	3/4 in. dia washer; 0.281 in. hole	−4.6	28.3	10 ±10%	4.1	150	2.5 amp	15	150	6.95 ±4.5%
13X1	3/4 in. dia washer; 0.281 in. hole	−4.6	89	31.5 ±10%	12.8	150	1.5 amp	15	190	6.95 ±4.5%
21E1	0.4 in. dia disk	−4.6	283	100 ±10%	40.7	150	600 ma	12	90	6.95 ±4.5%
21W1	3/4 in. dia washer; 0.281 in. hole	−5.2	327	100 ±10%	36	150	1.2 amp	15	150	9.1 ±3%
23W1	3/4 in. dia washer; 0.281 in. hole	−5.2	1,030	315 ±10%	113	150	600 ma	15	190	9.1 ±3%
31D1	0.4 in. dia disk	−5.2	3,270	1,000 ±10%	360	150	250 ma	12	90	9.1 ±3%
31D2	0.2 in. dia disk	−5.2	3,270	1,000 ±10%	360	150	250 ma	10	12	9.1 ±3%
Beads (Unmounted)										
32A5	Glass-coated bead 0.015 in. dia; 0.001 in. leads opposite	−4.0	5,000	1,000 approx.	900	150	25 ma	0.1	1	5.6 approx.
32A12	Glass-coated bead 0.045 in. dia; 0.004 in. leads adjacent	−4.6	5,800	2,000 ±20%	800	300	100 ma	0.7	2	7.3 ±10%
32A13	Glass-coated bead 0.045 in. dia; 0.004 in. leads opposite	−4.6	5,800	2,000 ±20%	800	300	100 ma	0.7	2	7.3 ±10%
51A2	Glass-coated bead 0.045 in. dia; 0.004 in. leads adjacent	−5.6	355,000	100,000 ±15%	34,000	300	25 ma	0.7	2	10.3 ±8.5%
51A3	Glass-coated bead 0.045 in. dia; 0.004 in. leads opposite	−5.6	355,000	100,000 ±15%	34,000	300	25 ma	0.7	2	10.3 ±8.5%
Beads in Glass Probes										
32A1	Bead on 0.07 x 2 in. glass probe	−4.6	5,800	2,000 ±20%	800	300	100 milliwatts	1	25	7.3 ±10%
51A1	Bead on 0.07 x 2 in. glass probe	−5.6	355,000	100,000 ±15%	34,000	300	100 milliwatts	1	25	10.3 ±8.5%

[1] The maximum continuous current or power is that which should not be exceeded to avoid damage to the thermistor. The value shown is approximate. It is based on some assumed method of mounting, usually with the thermistor suspended by its own leads in still air. For some other mounting in which the thermistor dissipates heat more readily (in moving air, or in oil, or against a metal block) more current than that shown can be passed without heating the thermistor above its safe operating temperature. In applications involving temperature measurement, compensation, or control it may be desirable to limit the thermistor current to 10^{-4} or 10^{-5} times the value shown to avoid any rise in temperature of the thermistor above the temperature of its surroundings.

[2] The temperature rise of any electrical device is nearly proportional to the power dissipated by it. The dissipation constant is the number of milliwatts of electrical power which when dissipated by the thermistor cause its temperature to rise one degree centigrade above the temperature of its surroundings. The value shown is based on some assumed typical mounting as in 1. For other mountings which allow heat to be dissipated more readily, the dissipation constant can be ten or more times the value shown.

[3] The thermal time constant is the time required for the thermistor to cool, on open circuit, from 100 C above to 37 C above the temperature of its surroundings. The value shown is based on an assumed typical mounting as in 1. For other mountings which allow heat to be dissipated more readily, the time constant may be only 1/10 or less of the value shown. When a thermistor is used to achieve a time delay in an electric circuit (thermistor heating because of applied voltage) the time delay achieved may be as small as 10^{-1} or 10^{-2} times the thermal time constant depending on the circuit.

[4] The figure shown is the cold resistance at 0 C divided by the cold resistance at 50 C, along with a manufacturing tolerance on this ratio. The tolerance on this ratio is important in determining the interchangeability of two stock thermistors of the same code number.

thermometer.

Another form of probe consists of a thermistor bead sealed in the end of a glass rod. Typical glass probes are shown in Fig. 4, together with a packing gland used for mounting these probes.

Washer type units are similar to disks without leads except for a central hole used for bolting the thermistor into position, Fig. 3.

The small bead-type thermistors are usually furnished glass coated with platinum alloy leads. These beads can be used in corrosive atmospheres or embedded in solid objects.

TYPE SELECTION FACTORS

Size, response time, maximum rated temperature and precision of manufacture are some of the factors involved in selecting the proper type thermistor.

The response time of a thermistor is closely related to its size and also to the mounting arrangements and operating conditions. The smallest bead type unit has a diameter of 0.007 in. without glass coating. The same bead with glass coating is only 0.015 in. in diameter. This unit has a fast thermal time constant of about 1 sec when supported by its own leads in still air. The time constant is less in moving air, or in oil, or when the unit is embedded in another object whose temperature is to be sensed. Some of the large washer type thermistors (for example, ¾ in. in diameter) have thermal time constants of 2 or 3 min. This figure can be reduced by bolting the washer thermistor to a thermal sink.

Maximum rated temperature depends on whether a unit is glass coated and whether it has attached leads. Disks and rods with leads are usually rated at 125 C continuous ambient temperature. The same units without leads are rated at 150 C. Glass coated beads will withstand 300 C continuously. The types with soldered leads are limited by the melting point of the solder. Types without soldered leads will not be destroyed by exposure to higher temperatures for short periods, but may show a slight permanent resistance shift.

The basic thermistor is sintered in air at a temperature between 1,200 and 1,400 C during manufacture. Disks, washers and rods are metalized at a temperature of 650 C and beads are glass coated at 850 C so that the maximum ratings are conservative.

The precision with which the various types of thermistors can be manufactured is another factor in the choice of proper type. Disks, washers, and rods are usually furnished with a 10 percent resistance tolerance at a specified temperature, while beads are furnished with a 15 or 20 percent resistance tolerance at a specified temperature. Disks and washers can be furnished to a greater precision at a slight increase in cost, since they can be ground in manufacture, reducing their diameter, and thus adjusting their resistance. Thermistor disks have been furnished in quantity with a resistance accuracy of 0.25 percent. Bead types are difficult to produce to higher precision because of their small size, and consequently are usually only furnished at higher precisions by simple selection and at consequent increase in price.

The tolerances discussed above are the variations encountered from unit to unit. A given unit will repeat its performance indefinitely over a 100 C range without detectable hysteresis or variation. The tolerances may seem high compared to the tolerances normally associated with wire resistance thermometers; however, the ten times higher temperature coefficient of the thermistor permits ten times the resistance variation for the same temperature accuracy.

In terms of temperature accuracy, disks, rods, and washers are usually furnished with a given resistance within about 2 C of a specified temperature. Disks have been furnished with a precision of 0.05 C.

Another type of precision has to do with the difference from unit to unit in following the nominal resistance-temperature curve specified by the manufacturer. This departure from the curve (or tolerance on temperature coefficient) is about plus or minus 0.5 C over a 100 C range for disks and rods, and about plus or minus 2.5 C over a 100 C range for beads. Again this tolerance refers to variations from unit to unit; a given unit reproduces without detectable change.

In Table I is listed the characteristics of typical thermistors available as stock items from one manufacturer.

POWER RATING

The factor most commonly overlooked in the application of thermistors is the power level at which the unit is operated. Normally thermistors must be operated at much lower power levels than other resistors would be. When an ordinary resistor is rated at one watt, this rating implies that one watt will not damage the resistor even though it may heat it as much as 100 C above ambient temperature. A thermistor of the same size may also not be damaged by one watt, but the fact that it has been heated to 100 C above ambient temperature is not conductive to accurate measurement of the ambient temperature.

As a result, the maximum power rating of a thermistor is usually not as important as a knowledge of its actual temperature rise when dissipating a given amount of power. There is a proportionality between the dissipated power and the temperature rise, that is usually expressed as a "dissipation constant" of so many milliwatts of electrical power per resultant degree Centigrade rise in temperature. The exact specification of the dissipation constant is difficult since it depends on the environment and method of mounting the thermistor. The value given is usually that which applies when the thermistor is suspended by its own leads in still air. The same thermistor in oil, or in moving air, or clamped to some other object may have a dissipation constant ten or more times the value given for still air.

In actual design there is no objection to allowing the thermistor to run slightly hotter than its surroundings, since this method achieves maximum output or sensitivity. However, temperature rise should be restricted to at most a few times the accuracy of temperature to which the measurement is to be made. Otherwise, undesirable effects such as long warm-up time or variation in readings can result.

Coupling of Parallel Shafts

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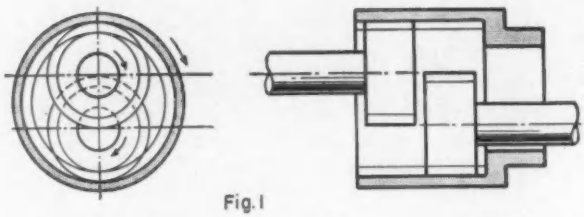

Fig. 1

FIG. 1—A common method of coupling shafts is with two gears; for gears may be substituted chains, pulleys, friction drives and others. Major limitation is need for adequate center distance; however, an idler can be used for close centers as shown. This can be a plain pinion or an internal gear. Transmission is at constant velocity and axial freedom is present.

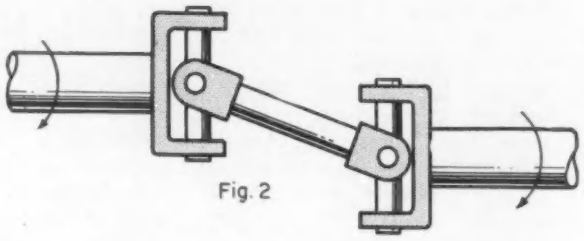

Fig. 2

FIG. 2—Two universal joints and a short shaft can be used. Velocity transmission is constant between input and output shafts if the shafts remain parallel and if the end yokes are disposed symmetrically. Velocity of the central shaft fluctuates during rotation and at high speed and angles may cause vibration. The shaft offset may be varied but axial freedom requires a splined mounting of one shaft.

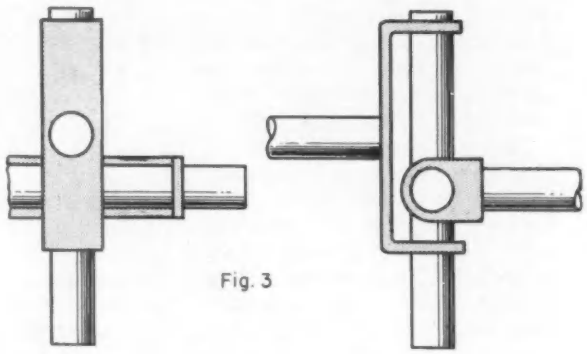

Fig. 3

FIG. 3—Crossed axis yoke coupling is a variation of the mechanism in Fig. 2. Each shaft has a yoke connected so that it can slide along the arms of a rigid cross member. Transmission is at a constant velocity but the shafts must remain parallel, although the offset may vary. There is no axial freedom. The central cross member describes a circle and is thus subjected to centrifugal loads.

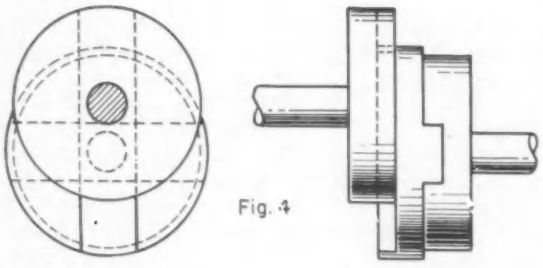

Fig. 4

FIG. 4—Another often used method is the Oldham coupling. The motion is at constant velocity, the central member describing a circle. The shaft offset may vary but the shafts must remain parallel. A small amount of axial freedom is possible. A tilting action of the central member can occur caused by the offset of the slots. This can be eliminated by enlarging the diameter and milling the slots in the same transverse plane.

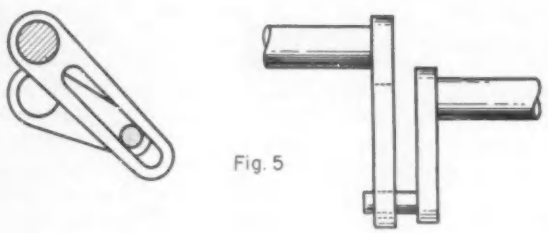

Fig. 5

FIG. 5—If the velocity does not have to be constant a pin and slot coupling can be used. Velocity transmission is irregular as the effective radius of operation is continually changing, the shafts must remain parallel

The coupling of parallel shafts so that they rotate together is a common machine design problem. Illustrated are several methods where a constant 1:1 velocity ratio is possible and others where the velocity ratio may fluctuate during rotation. Some of the couplings have particular value for joining two shafts that may deflect or move relative to each other.

unless a ball joint is used between the slot and pin. Axial freedom is possible but any change in the shaft offset will further affect the fluctuation of velocity transmission.

FIG. 6—The parallel-crank mechanism is sometimes used to drive the overhead camshaft on engines. Each shaft has at least two cranks connected by links and with full symmetry for constant velocity action and to avoid dead points. By using ball joints at the ends of the links, displacement between the crank assemblies is possible.

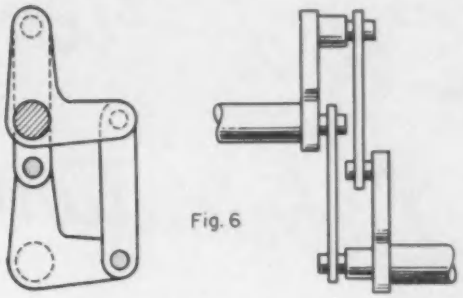

Fig. 6

FIG. 7—A mechanism kinematically equivalent to Fig. 6, can be made by substituting two circular and contacting pins for each link. Each shaft has a disk carrying three or more projecting pins, the sum of the radii of the pins being equal to the eccentricity of offset of the shafts. The lines of center between each pair of pins remain parallel as the coupling rotates. Pins do not need to be of equal diameter. Transmission is at constant velocity and axial freedom is possible.

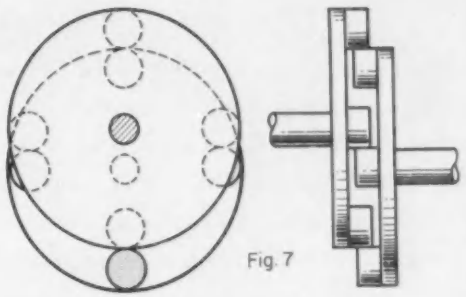

Fig. 7

FIG. 8—Similar to the mechansm in Fig. 7, but with one set of pins being holes. The difference of radii is equal to the eccentricity or offset. Velocity transmission is constant; axial freedom is possible, but as in Fig. 7, the shaft axes must remain fixed. This type of mechanism is sometimes used in epicyclic reduction gear boxes.

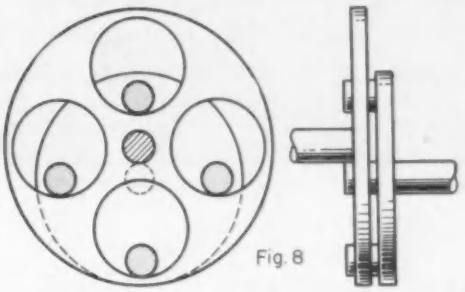

Fig. 8

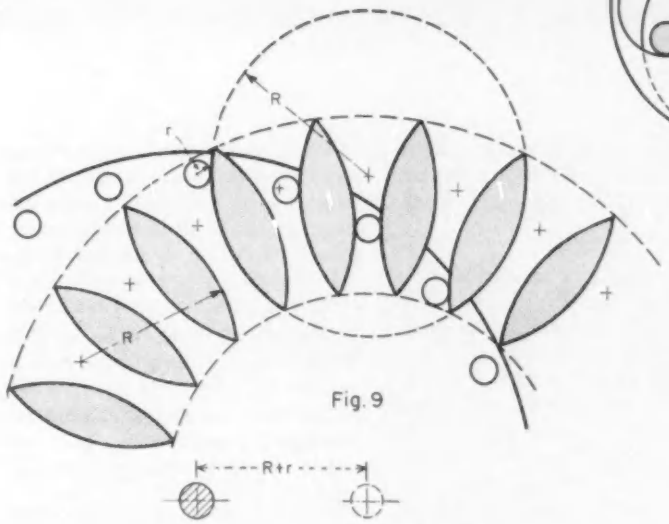

Fig. 9

FIG. 9—An unusual development of the pin coupling is shown left. A large number of pins engage lenticular or shield shaped sections formed from segments of theoretical large pins. The axes forming the lenticular sections are struck from the pitch points of the coupling and the distance R + r is equal to the eccentricity between shaft centers. Velocity transmission is constant; axial freedom is possible but the shafts must remain parallel.

Solid Film Lubrication

Whenever design conditions make full-fluid lubrication impractical, a boundary lubricant, either liquid or solid, must be used. Though the liquid medium is often preferable, there are many situations wherein a solid lubricant is the only solution. Typical are applications that involve wide temperature variations, mechanisms that must function after prolonged storage, and equipment in which liquid contamination cannot be tolerated.

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FROM THE FRICTIONAL point of view, the mechanism of lubrication by liquid and solid lubricants is the same; in each case, a thin solid film separating the surfaces is sheared during sliding. Fig. 1 shows two metal surfaces in contact under an applied load. The prominences and depressions in the adjacent surfaces produce initial contact at the "high spots." But as full load is applied, pressures at these small areas exceed by far the elastic limit of the metals, causing plastic flow at the points of contact. Plastic flow ceases when the total sq-in. area of contact A is represented by the equation

$$L = pA \qquad (1)$$

where L is the load in pounds and p the flow pressure of the metal which is about three times its ultimate tensile strength in lb per sq inch.

The real area of contact A is independent of the apparent contact area and is often a very small percentage of it. For example, if two flat mild steel surfaces, each an inch square, are placed in contact under a load of 10 lb, the real area of contact A is only 4.0×10^{-5} sq inch.

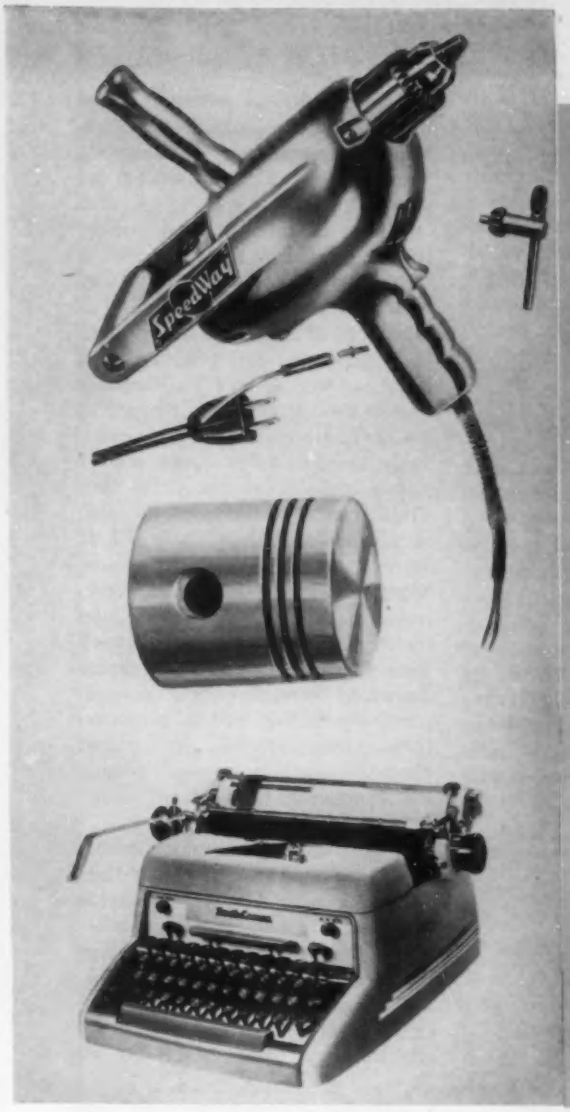
When clean metal surfaces are pressed together, welds nearly equal in strength to the bulk metal are formed at the junctions. These welds must be sheared off before sliding can occur, and the force to do this is the shear strength s_m of the junction multiplied by A. The friction force F_m then becomes

$$F_m = As_m \qquad (2)$$

and the friction coefficient f_m obtained from Eqs (1) and (2) is

$$f_m = F_m/L = s_m/p \qquad (3)$$

Since s_m and p are related plastic properties of the same metal, their ratio will be of the same order of magnitude



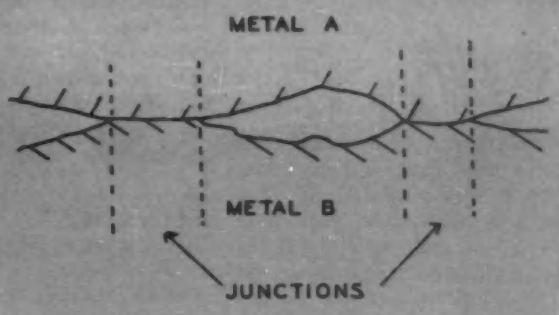


Fig. 1—Enlarged cross-section of two clean metal surfaces pressed together. Cold-welded junctions are formed during plastic flow at their contacting high spots.

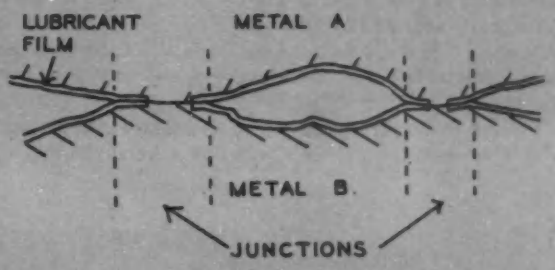


Fig. 2—Enlarged cross-section of lubricated metal surfaces. A thin lubricant film separates the metals over a portion of the junctions, but at some points the film has failed and welding has occurred, resulting in wear.

for all metals. In fact, coefficients of friction of 0.5 to 2.0 apply to all carefully cleaned metals; e.g., indium—2.0, copper—1.3, lead—1.1, steel—0.6, titanium—0.5.

Sometimes a welded junction is so strong that it does not shear exactly along the original line of demarcation between the surfaces. In such cases, a welded fragment is transferred from one surface to the other and wear takes place. Since strong welds are easily produced between two specimens of the same metal, the use of the same metal for both sliding surfaces results in strong welds and much wear; unlike metals, weaker welds and less wear.

FRICTION OF LUBRICATED SURFACES

When a thin film of solid lubricant is applied, an additional friction factor is introduced. Much of the contact between surfaces takes place through the lubricant film, although there is still some metal-to-metal contact as shown in Fig. 2. If the lubricant film has a shear strength lower than that of the metal, the coefficient of friction will be reduced. Designating α as the fraction of the real contacting area over which metal-to-metal contact exists, and s_1 as the shear strength of the lubricant film, the friction force for the lubricated surface is

$$F_1 = A\,[\alpha\, s_m + (1 - \alpha)\, s_1] \qquad (4)$$

and the reduction in friction for very thin films becomes

$$F_1/F_m = \alpha + (1 - \alpha)\, s_1/s_m \qquad (5)$$

The value of s_1 in Eqs (4) and (5) is the shear strength of the lubricant at the flow pressure of the metal, which is usually far greater than the shear strength at atmospheric pressure.

If a large reduction in friction is to be achieved, the lubricant must produce two conditions: a small value of α and a low ratio for s_1/s_m (hereafter designated as γ). Since α is a measure

of the penetration of the lubricant film by the metal asperities, the lubricant should adhere tightly to the surface and not flake off or wipe aside. And to achieve a low γ, the lubricant should be much softer than the metal and hence more easily sheared.

EFFECT ON WEAR OF LUBRICANTS

Reduction in α leads to less wear, and as a rough approximation, the reduction in wear is equal to $\alpha^{3/2}$. For example, metallic soap lubricants often reduce α to as little as 1/750 of the value for unlubricated surfaces and the wear to as little as 1/20,000. But the reduction in friction is only to 1/14, this being essentially the value of γ, which is a function of shear.

It should be noted that reduction of friction and reduction of wear do not necessarily go together. Friction is determined by two factors, α and γ while wear is influenced by only one, namely $\alpha^{3/2}$. For well-lubricated surfaces, α is much less than γ, indicating in this instance that friction and wear are independent phenomena. For poorly lubricated surfaces when α is the main factor, friction and wear are closely related.

While the type of wear discussed above is mechanical wherein small-scale welding takes place during sliding, there are other sources of wear. Principal among these is corrosive wear, which in many applications is predominant. If such corrosion leads to the formation of a chloride or sulfide film having low shear strength, low friction will be accompanied by high corrosive wear.

STICK-SLIP PHENOMENON

Besides reducing friction and wear, a good lubricant has a third function, that of eliminating stick-slip. This form of relaxation oscillations shows itself in such phenomena as the squeaking of door hinges and the jerky motion of mechanisms operating at slow speed. Analysis shows that stick-slip can be completely avoided if the static friction coefficient corresponding to the force necessary to start sliding is no greater than the kinetic coefficient corresponding to the force needed to maintain motion.

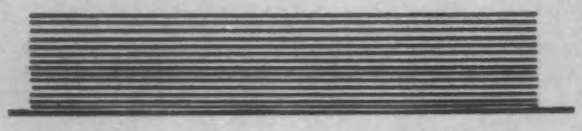


Fig. 3—Metal surface covered by a layer-lattice film. During sliding, the sheets of atoms move easily over one another and friction is low. Running-in helps to line up these sheets parallel to the surface.

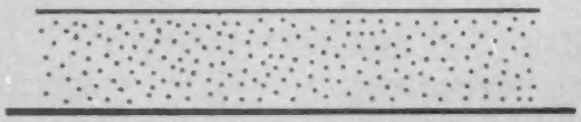


Fig. 4—Soft metal films on hard substrate have a uniform structure. Shear takes place within the film rather than in the hard substrate.

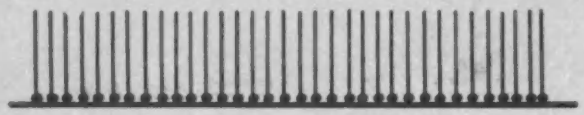


Fig. 5—Long-chain organic molecules have one reactive end (shown by dot) firmly anchored to the metal surface. Other end is inert and slippery, and readily slides past the facing surface.

INORGANIC FILM LUBRICANTS

The first class of lubricants which meet the frictional requirements enumerated above includes the inorganic films consisting of oxides, sulfides and phosphates.

Almost all exposed metal surfaces become covered by an oxide film, the nature and thickness of which varies with the metal. Most of these lubricate poorly as they are brittle and thus easily penetrated during sliding (α is high), as well as hard and therefore high in shear strength (γ is large).

Chemical reagents are used extensively to replace the oxides with a sulfide, chloride or phosphide film. The formation of these chemical coatings is induced by the addition of E. P. agents to lubricating oils and greases. Whenever normal lubrication breaks down, the resulting high temperatures initiate formation of these inorganic films which re-establish good sliding conditions. Similarly, cutting lubricants containing chlorine and sulfur derivatives increase tool life. And porous phosphate coatings on steel enhance the retention of lubricant, oil, grease or soap, thereby reducing wear.

In general, these inorganic films are limited in their use. Though their values for α are low, γ is often too high, and care must be taken to minimize corrosion. But the fact that these films are formed at the sliding surface itself means that they do afford protection where other lubricants are ineffective.

LAYER LATTICE FILMS

Graphite and molybdenum disulfide have a layer lattice structure consisting of strongly bonded sheets of atoms weakly bonded perpendicular to the sheet. Thus, when the sheets are lying flat on a metal surface, Fig. 3, the lateral strength prevents penetration of the film and α is low. At the same time, the weak bond between the sheets facilitates shear, and γ is low.

A disadvantage of these films is that they are not too firmly bonded to the metal surface. During sliding, a thin polished layer is formed on the sliding surface, but it tends to be pushed aside and eventually removed during long repeated sliding over the same track. Hence for applications in which long life under continued slid-

Table I—Various Types of Dispersion-Type Lubricants

Dispersed Substance	Carrier	Diluent	Typical Applications
Colloidal graphite	Water	Water	General industrial uses (Meets U. S. Army Specification 2-130)
	Petroleum oil	Petroleum oil	General industrial uses (Meets U. S. Military Specification MIL-L-3572, Grade B)
	1, 3-butylene glycol	Glycols, water	Rubber lubricant
	Alkyd resin solution	Aromatic petroleum naphtha	General-purpose dry-film lubricant
	Wax emulsion	(Water)	Dry lubricating film for heating element on hot-water heaters
	Alcohol (isopropanol)	Alcohols, esters, ketones	Electrically conductive coating (for static bleeding, etc.); dry-film lubricant (for press-fitting operations, for degreaser chains, etc.)
	Polyalkylene glycol (water-insoluble)	Polyalkylene glycol (water-insoluble)	Extreme-temperature lubricant (for bearings of kiln-car wheels, etc.)
	Mineral spirits	Petroleum naphtha, petroleum oil	General high-temperature lubricant (for conveyor chains and bearings, etc.)
Semi-colloidal graphite	Alkyd resin solution	Aromatic petroleum naphtha	Dry-film lubricant (for camera shutters and auto-door locks), stop-off coating for casting
	Petroleum oil	Petroleum oil	Formulation of forging lubricants; for plungers of die-casting machines, etc.
	Petroleum oil	Ready for use	Graphite anti-seize compound (for screw threads, etc.) meeting U. S. Military Specification MIL-C-907
Graphite	Mineral spirits	Petroleum naphtha, petroleum oil	General high-temperature lubricant
Molybdenum disulfide	Alcohol (isopropanol)	Alcohols, esters, ketones, etc.	Dry lubricating films; anti-seize
	Petroleum oil	Ready for use	Molysulfide anti-seize compound (for screw threads, etc.) meeting U. S. Military Specification MIL-C-907
	Polyalkylene glycol (water-insoluble)	Polyalkylene glycol (water-insoluble)	Extreme-temperature lubricant (for oven conveyors, etc.)
Colloidal molybdenum disulfide	Petroleum oil	Petroleum oil	Extreme-pressure and high-temperature lubricant
Zinc oxide	White oil	Petroleum oil	Formulation of special-purpose lubricants

Acheson Colloids Company

ing is required, it is advisable to use the lubricant dispersed in a varnish or resin binder. Such combinations have most of the low-friction characteristics of the pure lubricant, but exhibit greatly increased resistance to wear and, in many cases, resistance to corrosion.

The inorganic films generally have high melting points. Graphite and molybdenum disulfide remain solid to very high temperatures, Table I, and oxidation is the limit to their utility. Up to 750 F, they can be used indefinitely, and for short periods to far higher temperatures. At temperatures above 900 F, graphite is preferrable, since its product of oxidation is carbon dioxide gas, while that of molybdenum disulfide is an abrasive oxide.

SOFT METAL FILMS

Metals such as indium, cadmium and lead have low coefficients of friction (0.1) when used as thin films on hard metals like steel, Fig. 4. When the optimum film thickness for a given application is utilized, the values of both α and γ can be made low. A good example of the effectiveness of these films is the thin lead film on silver used in the bearings of aircraft equipment.

The soft metals will lubricate up to their melting points—320 F for indium, 620 F for lead and 610 F for cadmium. Softening and oxidation may present problems in the range just below these temperatures.

LONG-CHAIN ORGANIC MATERIALS

Oils, greases and soaps have been adopted for solid film usage. Strongly bonded to metal surfaces by chemical forces, they often have very small

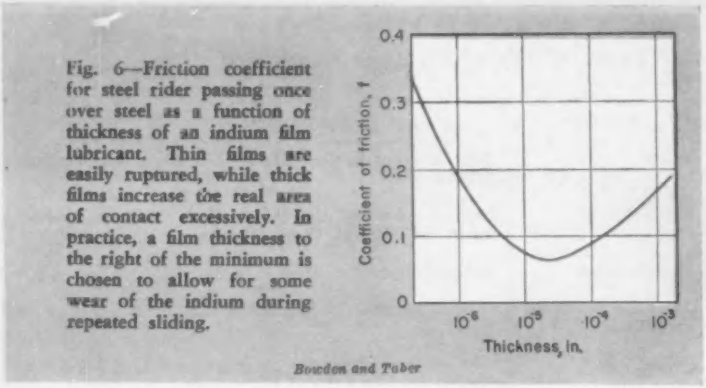


Fig. 6—Friction coefficient for steel rider passing once over steel as a function of thickness of an indium film lubricant. Thin films are easily ruptured, while thick films increase the real area of contact excessively. In practice, a film thickness to the right of the minimum is chosen to allow for some wear of the indium during repeated sliding.

values of α, and, because of their low shear strength, low coefficients of friction. They take on good lubricity after being dissolved in weak concentrations of other fluids.

Fatty acids and their derivatives are major constituents of organic fats and oils. They are long, straight-chain hydrocarbon molecules with one reactive end. At room temperatures, they are adsorbed on metal surfaces as a dense carpet with the reactive end firmly attached to the surface and the rest of the molecule extended at right angles to the surface, Fig. 5. Palmitic acid with 16 carbon atoms in the chain and stearic acid with 18 atoms are two of the most important fatty acids. Cheap and efficient, they are widely used for wire-drawing, as additives in mineral oils for general-purpose boundary lubrication, and in greases and soaps as solid lubricants.

The temperature behavior of organic materials is complicated. A long-chain acid such as palmitic should fail as a lubricant at its melting temperature of 145 F. Instead, it reacts with most metals to form soaps having melting points of 240 F and higher. Thus lubrication with these fatty acids, either dry or dissolved in a mineral oil, is effective to the higher temperature.

Many calcium and sodium-based greases are hydrous and the temperature limit to their use is set by the evaporation of the constituting water (180 F). In others, melting of the soap (240 F and upward) and oxidation of the oil (320 F and upward) limit high temperature use. Special barium and strontium greases are best at high temperatures, while lithium greases can be used at low temperatures.

SOLID FILM SYNTHETICS

Like the organic lubricants, the silicones, polyalkylene glycols and fluorocarbons, are based on the long-chain idea. But the chains are modified by the addition of oxygen, the substitution of fluorine for hydrogen, or the use of silicone rather than carbon. Their outstanding advantage is superior behavior at high and low temperatures, while their main disadvantage is higher cost.

As solid films are heated, they gradually become softer and then melt, often at a sharply defined temperature. During the softening phase α increases because the softer film is more easily penetrated, and γ decreases as a result of the film becoming more easily sheared. The result is less friction.

But when the film melts, a striking change takes place. The molten lubricant is easily pushed aside, the value of α goes up, and both friction and wear increase considerably. In the range just above the melting temperature, the lubricant affords limited protection, while at higher temperatures, the surface bond is too weak. Friction and wear then attain values indicative of no lubrication at all.

EROSION OF LUBRICANT FILM

One of the basic problems in solid film lubrication is the replenishment of lubricant, which is slowly worn away during sliding. When a liquid lubricant is used, there is normally no problem, but in the case of solid lubricants, their limited mobility leads to difficulties. The partial protection of surface oxides does persist during sliding, because the initial layers of oxide films form almost instantaneously whenever bare metal is exposed. Non-oxide solid films are not reformed automatically and thought must be given to the possibility of their removal by wear.

The simple expediency of applying initially a thick film which will not be worn away for a long period of time would not be effective in all cases. Eq (5) for the reduction in friction force applies only to very thin films. If the film is made thick, the real area of contact A becomes larger because the load is borne partly by the lubricant, rather than by the base metal. The curve in Fig. 6 shows the optimum thickness for soft films.

It is sometimes puzzling that hard metals like chromium, *and* soft metals like cadmium are advocated as friction and wear reducers. In line with the principle just stated, chromium plating is made relatively thick (10^{-3} in.) so that the chromium case carries the load and the lower wear characteristic of the harder metal is utilized. Cadmium plating is made comparatively thin (10^{-4}) so that the underlying steel carries the load and the low shear strength of cadmium reduces friction.

SELF-GENERATION OF LUBRICANT LAYERS

In its simplest form, this method utilizes reservoirs of solid lubricant placed along the sliding surface. Lubricant is spread over the surface to replenish lubricant removed during sliding. Typical examples are gridded copper bearings in which grooves are filled with lead.

The solid lubricant is also incorporated within the metal structure. In copper-lead bearing alloys, the lead is trapped as globules inside the copper matrix. It is then gradually squeezed out during sliding and smeared on the surface to provide lubrication.

In addition to these examples in which the lubricating solid is naturally present in the metal structure, there are many applications in which the metal is made porous by powder metallurgy techniques and the lubricant introduced to fill the hollows in the structure. Powdered bronze and iron bearing impregnated with oil, soap or graphite are used in small motors, and it is reported that Teflon is being considered for a similar role.

Perforated Materials For Functional Uses

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PERFORATING OF MATERIALS is not in itself new, but the requirements of better product design have stimulated the development of precision perforating in sheet, plate, and coil materials. A broad range of type, size, shape and spacing of perforations provides at least a partial answer to problems involving light, air, or liquid passage; noise level reduction; screening, sifting and filtering; protection and ventilation of electrical and moving parts; and decoration.

Precision perforating can produce, in metallic and non-metallic materials, round holes and slots to an accuracy of 0.0005 in., when required, with holes 0.020 in. diameter and slots 0.006 in. wide, and ranging up to 9 in. diameter. However, the usual application requires a size accuracy of only a few thousandths of an inch. Resulting perforated designs vary from circular holes to crescent shapes, in thousands of patterns, and can be produced in material thickness varying from 0.005 to 1.0 in., depending on the material.

In addition to extreme precision of

hole size, and broad pattern selection, there are several other important advantages offered by perforated materials. Compared to other methods of obtaining open area, the process is relatively inexpensive. Smooth, safe margin edges can be provided. Holes can be restricted to certain areas, and produced so that the smallest dimension of the hole is at the top surface, thus making an excellent screening medium. Perforated materials will not unravel, as do those woven, and, possessing a smooth surface, they are easy to clean, especially when fibrous products are being screened. In addition, they are easy to form, weld, solder, braze and fabricate by methods conventional to the material perforated.

Perforated Material Design

In designing for perforated materials there are a number of factors that establish perforating specifications. The major considerations are:

1. Type, gage, quality and availability of material. Since nearly every material that is produced in sheet, plate or coil form can be perforated, a wide range of material selection is afforded. However, since all perforations have certain gage, material, and width limitations, it is best to consult the supplier before creating a specification. It is usualy advisable to specify materials that are available in the standard sizes and thicknesses, unless quantities required warrant special rolling.

2. Dimensions of sheet or piece. As shown in Table I, there are certain sheet size limitations for different perforations. Generally, small area pieces are perforated in multiple and then sheared to size.

3. Type, size, shape, spacing and arrangement of perforations. The multitude of types, shapes and arrangements of standard perforations, Fig. 1, all of which can be produced in various sizes, offers considerable design latitude.

4. Position and dimensions of unperforated areas. When margins and blank areas are required, drawings should be prepared with permissable dimension allowances clearly indicated. Margin widths should be specified.

5. Quantity. Since "perforated-to-order" involves machine set-ups, lower item costs result from larger quantities, especially when the quantity of material involved is sufficient for a mill rolling. Large quantities also make the building of special perforating tools advisable in the interest of faster production. In such cases the perforation size, shape, and arrangement can, without extra cost, be other than standard.

Materials Perforated Thickness Limitations

Because of its combination of cost, strength, stiffness, and general acceptability in industry, steel is perforated more than any other material. The type of steel depends upon the service required. Steel up to 12 gage in thickness, and uncoated, should be cold rolled or hot rolled pickled; in heavier gages, it need not be free of scale unless surface finish is important. Steels coated with zinc, (galvanized—hot dip or electrolytic), lead, (terneplate) or tin, are used to resist corrosion.

Aluminum, because of its non-rusting quality and its strength-weight ratio, has become an important metal used in perforated form. Copper and its alloys, including brass and various bronze alloys, have long held their important positions as corrosion resistant perforated material. Monel metal is an important perforated material and a variety of stainless steel alloys are being perforated increasingly, as facilities for perforating them have been improved. Nickel, lead, and zinc are other metals being perforated while in the nonmetallics, plywood, composition board, vinyl sheet, polystrene sheet, thermosetting laminates and fluorocarbon plastics have also been perforated successfully.

In the selection of thickness, the dictating factors include: rigidity desired, abrasion- and corrosion-resistance to be met, initial and ultimate cost, perforating limitations, and appearance. The greater the open area resulting from perforating, the greater will be the loss in rigidity, stiffness and wear resistance. However, stiffness may be improved by securely fastening the perforated materials when they are put to use. It is well to note that any metal screen subject to vibration or flexing is apt to crystalize and crack. The use of thicker metal in such applications is advisable.

In screening operations, consideration must be given to the abrasive qualities of the material being screened. A thin screen has greater capacity but cost of replacing must be balanced against the first cost of a thicker screen and, in some applications, of special abrasion resisting alloys.

Corrosion often requires special

Fig. 1—Standard hole arrangements for perforated sheet. See Table I for percent of open area with various hole diameters.

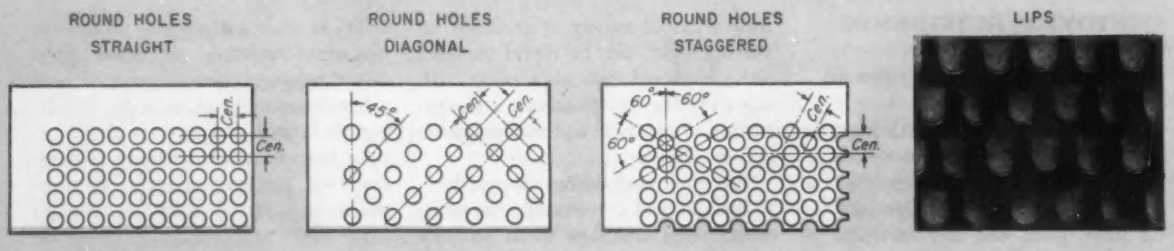
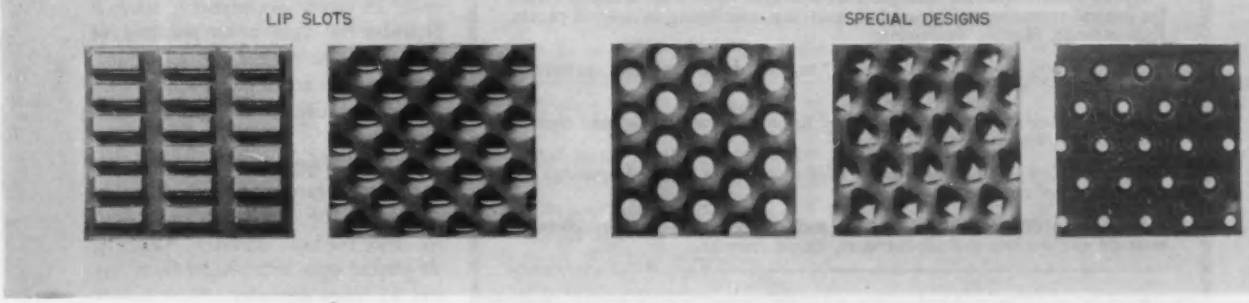


Table I—Hole Specification and Material Thickness for Standard Perforated Sheet

Hole		Percent Open Area	Max Sheet Width, in.	Gage of Sheet					
Diameter, In	Arrangement			Steel USS-R	Stainless USS	Brass B&S	Aluminum B&S	Copper BWG	Monel USS
0.020	Straight	30	14	32	34	24	24	22	28
			18	—	—	25	24	24	28
			24	—	—	26	24	25	—
			30	—	—	26	24	26	—
0.024	Straight	24	12	26	31	22	20	22	26
			18	26	31	22	20	22	26
			24	26	31	22	20	22	26
			30	26	32	24	20	22	26
0.027	Straight	23	12	24	29	22	20	20	25
			18	26	29	22	20	22	26
			24	26	29	22	20	22	26
			30	26	29	24	20	24	26
0.033	Straight	29	12	24	27	20	20	20	22
			18	24	27	20	20	20	24
			24	24	27	20	20	20	24
			30	24	28	22	20	22	26
0.040	Staggered	30	18	22	25	20	16	20	22
			24	24	26	20	16	20	24
			30	24	27	22	18	20	24
0.045	Straight	37	18	22	25	20	18	18	20
			24	22	25	20	18	20	22
			30	24	26	22	20	22	24
0.050	Straight	33	18	22	24	20	18	20	22
			24	22	25	20	18	20	22
			30	24	25	22	20	22	24
0.057	Straight	35	24	20	24	20	18	19	22
			30	22	26	22	20	20	24
0.0625	Staggered	30	36	16	20	14	14	16	18
			48	16	22	14	14	16	18
0.09375	Staggered	32	36	12	18	12	12	12	14
			48	14	18	12	12	14	16
0.125	Staggered	40	24	11	16	8	9	10	12
			36	12	16	8	9	11	12
			48	12	16	8	9	11	14
0.125	Staggered	23	36	10	16	8	8	10	12
			48	10	16	8	8	10	14
0.1875	Staggered	51	48	10	14	8	8	10	12
0.1875	Staggered	41	48	10	14	8	8	10	12
0.1875	Staggered	33	48	10	12	8	8	10	10
0.250	Staggered	35	48	3/16 in.	1/4 in.	1/4 in.	1/4 in.	1/4 in.	3/16 in.



coatings such as galvanizing or the use of heavier materials or special alloys. The first cost of thin unprotected steel sheets is low, but if good condition after long severe operating service is important, then it is necessary to carefully consider the gage and kind of material to specify. Perforating limitations insofar as gage is concerned are dependent upon the kind of material, its temper and width and how closely together the holes are spaced. For a given hole diameter, greater thicknesses of aluminum, brass and copper can be perforated than those of steel. Monel must be of a lesser gage than the hole diameter and stainless 18-8 of a still lighter gage. It will also be noted that narrow widths can be heavier and that a wider spacing of holes permits the perforating of heavier gages. For small holes up to 1/20 in. in diameter, the width limit is usually 24 or 30 inches. In general, larger perforations can be made in sheets as wide as 48 in. and in plates as wide as 108 in. Usually no restrictions are placed on the length of perforated sheets. The limits as shown by Table I can be exceeded under certain conditions. A general rule is that $\frac{1}{16}$ in. holes can be perforated in $\frac{1}{16}$ in. thick steel, but in stainless, the thickness should not exceed $\frac{1}{32}$ in. and in Monel should not exceed $\frac{3}{64}$ in. In brass, copper and aluminum, however, the thickness can be greater. For holes smaller than $\frac{1}{16}$ in., the metal thickness must be less than the hole diameter. As the diameters increase above $\frac{1}{16}$ in. however, the metal may be thicker. It is permissible to produce $\frac{1}{4}$ in. holes in $\frac{5}{16}$ in. steel and $\frac{1}{2}$ in. holes in $\frac{3}{8}$ in. steel.

Table II—Typical Application of Perforations

Use	Hole Dia. in.	Type	Percent Open Area	Purpose
Acoustical Panels	3/32 to 1/8	Round	6 to 12	Pass sound waves to absorbing material.
Loud Speaker Grilles	1/32 to 1/8	Round	25 to 35	Concealment, protection of speaker.
Cabinet Ventilation	3/32 to 3/16	Round, slotted, square, ornamental	30 to 50	Concealment, maximum airflow.
Room Heater Grills	5/8 to 9	Round	65 to 75	Protection of radiant heating elements.
Room Heater Cabinets	1/14 x 1/2 to 1/4 x 1 1/2	Oblong, ornamental	35 to 60	Providing convection and radiant surfaces.
Architectural Grilles	1/2 to 1	Square, ornamental	45 to 72	Decoration.
Machine Guards	1/2	Round	45 to 56	Operator and moving part protection.
Plate Guards	3/4 to 7/8	Round	35 to 50	Protection of earth-moving tractor radiators.

Table III—Typical Perforated Forms

Round holes—Standard arrangements, available up to 9 in. diameter. Used for general screening and separating, guarding, ventilating, acoustical panels, light passage, filtering processing.

Oblong slots—Available up to 5 by 7 in. Used for screening, ornamentation, increased open area.

Squares—Available up to 3¼ in. Used for architectural grilles and register faces, increased open area.

Lips and slots—Can be of various widths providing shielded openings for processing and air passage.

Special designs—Indented, stabbed, and tapered used for dry cleaning machine application, anti-slip surfaces, liquid transfer.

Selection of Perforation

The selection of the proper type, size, arrangement, and spacing of perforation depends primarily upon the application, Table II. In general, clean punched round holes are employed more frequently than any other shapes, for such applications as acoustical panels, cabinet ventilation, and machine guards. Cylinders used in washing and drying machines are generally perforated with indented round holes so that the edges of the holes are turned back to provide stiffness and a smooth inside contact surface. Slotted holes, and triangular holes, are widely used in sifting applications in process industries. Special crescent shaped indented holes, with a sharp lip on the contact side, are extensively used in pulping equipment. A wide selection of stabbed holes is used where an abraiding or non-slip surface is required. Special lip type slots, which offer a means of obtaining openings of variable widths in heavy steel plates are employed in well screen design. In screen applications, perforated types possess an advantage over the woven types in that the smooth edges of the screens require no binding or blocking out. In addition, since the perforated holes are separated by smooth solid metal, there is little chance that fibrous materials will adhere to the screen or become lodged between the wires as in woven screens. When the more generally used round holes are employed, there are three standard arrangements of perforations, Table III, straight with holes on 90 deg center lines, diagonal holes on 45 deg center lines, and staggered on 60 deg. The straight and diagonal patterns permit an alignment of the perforations when pieces are turned thru 90 deg. In the staggered arrangement, registration is only possible when pieces are turned thru 60 deg. However the staggered arrangement is most widely used, especially in larger perforations, since it provides the most holes per unit of area for given centers and all bridges between holes are of equal width. This provides maximum strength and uniform wear.

With the staggered arrangement, the open area, regardless of hole diameter, is always 22½ percent when centers are twice the hole diameter. Similarly, 40 percent open area results from centers 1½ times diameter.

Scale Factors for

ANALOG COMPUTERS

A technique is developed which permits a simple visualization of the scale factor problem in analog computers. This method allows the operation of time scaling to be considered apart from scale factor determinations. Both operations become routine, simple, and fast. A typical problem is shown to illustrate the technique.

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THE ELECTRONIC ANALOG COMPUTER is now a widely accepted tool for research and development. Many papers and articles have described the manifold types in commercial production as well as those which have been built by research groups. Suffice it to say here that in an analog computer, measured quantities, usually voltages, are caused to vary in the same way as do variables in a physical system. Thus the analog "computes" the solution to a problem by faithfully reacting exactly as would the original counterpart. Results produced by an analog may be applied to an actual problem with an accuracy that depends on the precision of computation and the degree to which the analog models the counterpart. It is this second factor which is to be considered here.

To model a system, an analog must have the same functional form (form of differential equation) and its parameters must be numerically determined. To interpret results, factors relating analog variables to system variables must be established. Most references on this subject concern themselves with techniques for providing functional similarity but sometimes leave the problem with actually determining the numbers to the ingenuity of the user.

One approach to the problem is to make all system parameters and variables dimensionless. This technique is not difficult to apply and often reveals many basic factors of importance in a study. At the same time, however, the effect of a particular parameter may sometimes be obscured. Design problems require the ultimate return to dimensional values. In particular, the application of non-dimensional techniques when certain nonlinearities are present is often difficult. For these reasons it appears that a procedure based on direct equivalences between analog voltages and system variables has practical value.

The Dual Analog technique is such a procedure. The electronic analog representing a physical system may be made to operate either at the same speed as its physical counterpart or it may operate either faster or slower. An analog operating at physical system speed is called a true-time analog. The name fast (or slow)-time analog is applied to the analog which does not run at the same speed as the original system.

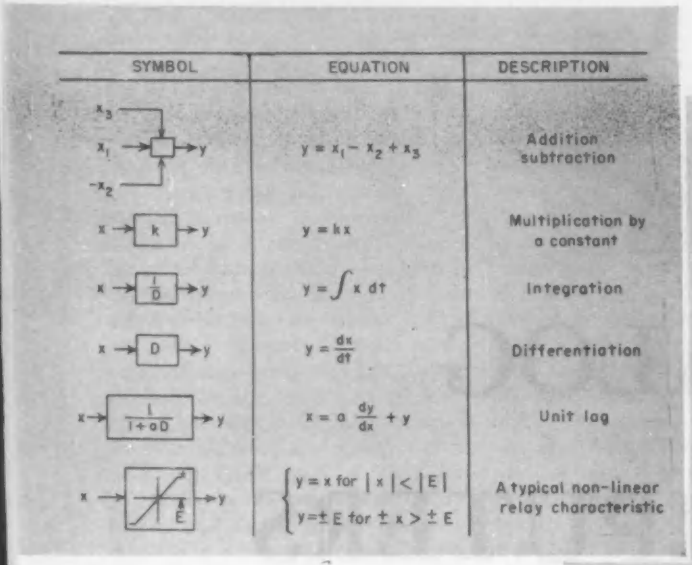
The importance of this time classification is derived from the fact that scaling of time does not occur between the true-time analog and its counterpart. Thus one need only concern himself with the determination of dimensional scale factors, determination which becomes a completely algebraic process.

It will be shown that once the true-time analog has been considered and scale factors determined, it is comparatively easy to account for slow or fast time operation.

The steps of the technique are then:

(1) Formulate a hypothetical true-time analog and determine scale factors and parameter settings.

(2) Transform the true-time set-up into an appropriate speed of operation.



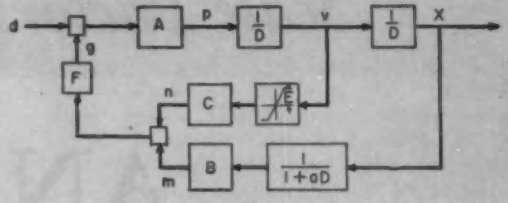
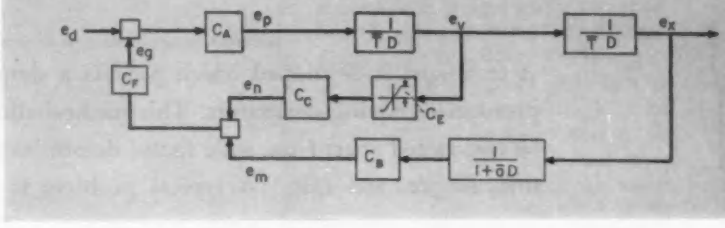


Fig. 1—Functional block diagram of a typical computer system. This represents a typical problem.

Fig. 2—An electronic analog of the functional system shown above, represented as a block diagram.



This procedure will be outlined in a somewhat general example and then illustrated with a numerical example.

Consider a typical problem involving addition and subtraction, multiplication by a constant, integration, simple or unit lag, and certain non-linearities. Fig. 1 shows a functional block diagram of a hypothetical system. The various operational symbols are explained in the insert and some variables are indicated at appropriate points on the diagram.

In the physical counterpart, variables must be measured in a consistent set of engineering units. The system parameters will then be defined in terms of the units of the variables which they relate. Thus, for example, since

$$n = Cv$$

where $[n] = [\text{lb}]$, $[v] = [\text{ft/sec}]$

then: $$[C] = \left[\frac{\text{lb}}{\text{ft/sec}}\right]$$

where [] = units of the parameter enclosed by the brackets.

An electronic analog of the system of Fig. 1 can be represented in a similar block diagram. However, it will have two important differences:

(1) Voltage magnitudes are used to represent all system variables and;

(2) Constants having the units [time^{-1}] appear before each operation of integration. (See Table I.)

The analog block diagram might then appear as Fig. 2, where

C_A, C_B, C_C, C_F are analog coefficient s e tings,

e_d, e_p, e_v, e_x, e_m, e_n, e_g are voltages representing variables,

$\overline{T}$ is the time constant of voltage integration ($\overline{T} = T$ on True-time analog

$\overline{\tau}$ is the time constant for electronic unit lag, ($\overline{\tau} = \tau$) on true-time analog

C_E is a limit in volts, and

k_d, k_p, k_v, k_x, k_m, k_n, k_g are factors relating system variables to analog voltages.

Consider now the true-time analog of the hypothetical system. The diagram of Fig. 2 becomes such an analog when $\overline{T} = T$ sec and $\overline{\tau} = \tau$ sec assuming the physical system variations are measured in seconds.

Visualize the analog block diagram operating in a plane which is parallel to the system diagram. If each block diagram, system and analog, is disturbed at the same time, each voltage in the analog will be in phase with its analogous variable in the physical system. In fact, if each voltage were fed into a "transducer" having an appropriate constant and unit transformation, the outputs of these "transducers" would be at every instant equal to the variables in the physical system. These "transducers" may be represented by operational blocks and may be assigned values which are identically the scale factors to be determined.

If these scale factor blocks are added to the parallel plane diagram of Fig. 2, a three dimensional block diagram results which contains all relations involving both scale factors and parameter settings. It is very significant that such a diagram will be dimensionally homogenous throughout its entirety. Such a diagram is shown in Fig. 3.

The relations which involve the analog parameter settings (C_n, etc), the scale factors (k_n, etc) the physical system parameters (n, etc), and the analog integrator time constants (T) may be formulated by equating the "gain" obtained by moving between equal signs via the physical system, to the "gain" obtained by moving between the same equal signs via the analog. For example in Fig. 3:

Between two and three

$$A = 1/k_d \cdot C_A \cdot k_p$$

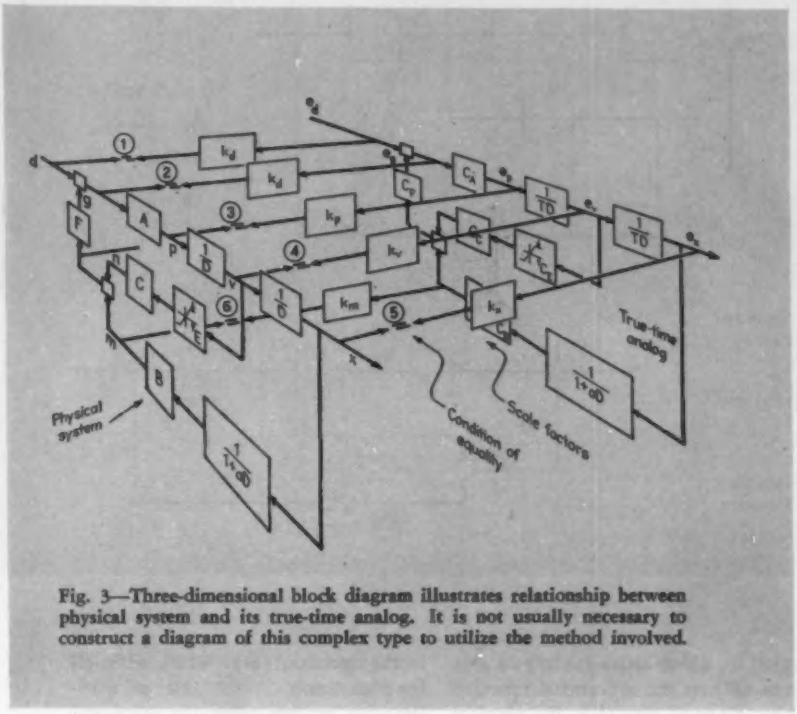


Fig. 3—Three-dimensional block diagram illustrates relationship between physical system and its true-time analog. It is not usually necessary to construct a diagram of this complex type to utilize the method involved.

similarly between two and four

$$A \cdot 1/D = 1/k_d \cdot C_A \cdot 1/TD \cdot k_a$$

and between four and five

$$1/D = 1/k_v \cdot 1/TD \cdot k_a$$

In most problems, the system parameters will be known numerically in terms of consistent units, however, the scale factors and analog parameter settings are to be determined. Since there will remain many more unknown than equations of the above type, it is necessary to designate certain unknowns and use a trial and error procedure to arrive at a final set of values. This operation is better illustrated in the numerical example which follows.

Some important conditions apply to the analog parameter settings which considerably restricts their range. These may be formulated as two requirements to be met in each setting:

(1) That it is a reasonable parameter setting, i.e., lies in the linear, accurate range of the coefficient unit, and,

(2) That it does not produce voltage variations which are too large to be handled by the computer or too small to be accurately measured.

Fortunately, both of these requirements are met by the single consideration that all coefficient settings be as close to unity as possible. Although this may seem a rather arbitrary requirement, when the action of most real systems in nature is formulated mathematically with an accuracy and significance consistent with the accuracy of measurement and determination of parameters, the so-called loop gains in a system will have similar orders of magnitude. The gain can usually be adjusted to a value near unity when time units are defined appropriately. In other words, a unit lag having a time constant 1/100th of another in a system will have little effect on the system's dynamic performance, or alternatively, a part of a system having a natural frequency 100 times that of another part will have small effect on studies made near the lower frequency. If, in an actual case, it is impossible to obtain coefficient settings near unity, (between say, 0.1 and 10) there is a strong possibility that some part of the problem is being formulated inconsistently.

The first step of the technique is now complete and there remains the problem of applying the results obtained for the hypothetical true-time computer to a fast or slow-time analog.

The key to this transformation lies in the fact that the analog can be considered as operating in any time units that may be desired. Thus it is con-

Table 1—System Integration vs Analog Integration

	System Integration of Velocity *	Analog Integration of Velocity **	Units
Equation	$x = \int v\,dt$	$e_x = \frac{1}{\bar{T}} \int e_v\,dt$	$X = [\text{in.}]$ $V = [\text{in./sec}]$ $e = [\text{volts}]$ $\bar{T} = [\text{sec}]$ $D = [\text{sec}^{-1}]$ $D = d/dt$ $\frac{1}{D} = \int dt\ [\text{sec}]$
Operation	$x = v\,\frac{1}{D}$	$e_x = e_v\,\frac{1}{\bar{T}D}$	

* Units are so defined that constant of integration is not required.
** Constant of integration required for dimensional consistency.

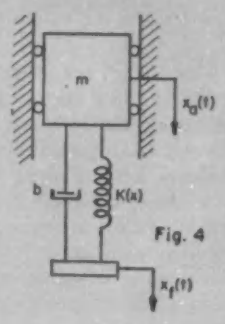


Fig. 4

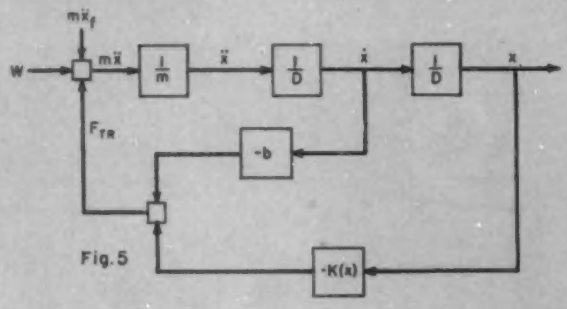


Fig. 5

Parameters and Inputs

$\frac{1}{m}$ = 386

b = 2.04

K(x) = 16 → 30

$m\ddot{x}_f$ = input

W = 1.0

Fig. 4—Schematic of the shock mounted damped structure used in text example.

Fig. 5—Functional block diagram for the system shown schematically in Fig. 4.

Fig. 6—Analog block diagram corresponding to the functional diagram of Fig. 5, above.

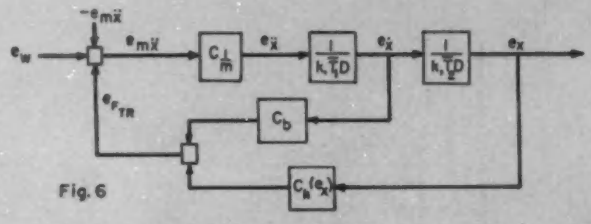


Fig. 6

venient to define a new unit of time for the analog—

the *asec* (for analog-second)

let 1 sec = $k_t \cdot 1$ asec

thus $k_t = \frac{1}{1}\frac{\text{sec}}{asec}$ and is the ratio of true-time to analog time.

Consider an analog operating (integrating, differentiating, etc.) in *asec* units. Where the differential operator D had units of [sec^{-1}] in the physical system and true-time analog, it will now have units of [$asec^{-1}$].

As explained previously, Table I, it is necessary for the time constants associated with electronic integration to have the same units as those ascribed to the operator, (D). Thus, when all time constants in the fast or slow-time analog are given the same numerical values as those in the true-time analog, but in terms of asec unit, the resulting block diagram will be identical to that of the true-time analog. Accordingly, all scale factors and parameter settings previously arrived at, may be applied directly. One asec then represents one second.

The choice for k_t (time scale factor) usually depends on a knowledge of the true length of time over which events are to be studied as compared with the length of time events are to be studied on the analog. Often this is the ratio of the periodic disturbance duration in the analog to the length of time for a system to reach equilibrium.

Suppose, for example, that a 40 millisecond square wave disturbance is to represent 10 seconds of real time. Then,

$$1[asec] = 4 \text{ [milliseconds]}$$

and,

$$k_t = \frac{1[\text{sec}]}{1[asec]} = \frac{1[\text{sec}]}{.04\ [\text{sec}]} = 25$$

If each time constant of integration in the true-time analog is T [sec] then each similar time constant in the fast time analog should be $\overline{T}$ [$asec$] or $T/25$ [sec]. Other time constants as

Table II — Calculations for True-Time Analog

Path	Relationship	Chosen Values	Determined Values
③ ①	$\frac{1}{k_x} \cdot C_b \cdot K_f = 2.04$	$k_f = 1\ \left[\frac{\text{lb}}{\text{volt}}\right]$ $k_{\dot{x}} = 1\ \left[\frac{\text{in/sec}}{\text{volt}}\right]$	$C_b = 2.04$
① ②	$\frac{1}{k_f} \cdot C_{\frac{1}{m}} \cdot k_{\ddot{x}} = 386$	$k_{\ddot{x}} = 100\ \left[\frac{\text{in/sec}^2}{\text{volt}}\right]$	$C_{\frac{1}{m}} = 3.86$
② ③	$\frac{1}{k_{\ddot{x}}} \cdot \frac{1}{T_1 D} \cdot k_{\dot{x}} = \frac{1}{D}$		$T_1 = \frac{1}{100}$ [sec]
④ ①	$\frac{1}{k_x} \cdot C_k(e_x) \cdot k_f = (16 \to 30)$	$k_x = \frac{1}{10}\ \left[\frac{\text{lb/in.}}{\text{volt}}\right]$	$C_k(e_x) = 1.6 \to 3.0$
③ ④	$\frac{1}{k_{\dot{x}}} \cdot \frac{1}{T_2 D} \cdot k_x = \frac{1}{D}$		$T_2 = \frac{1}{10}$ [sec]

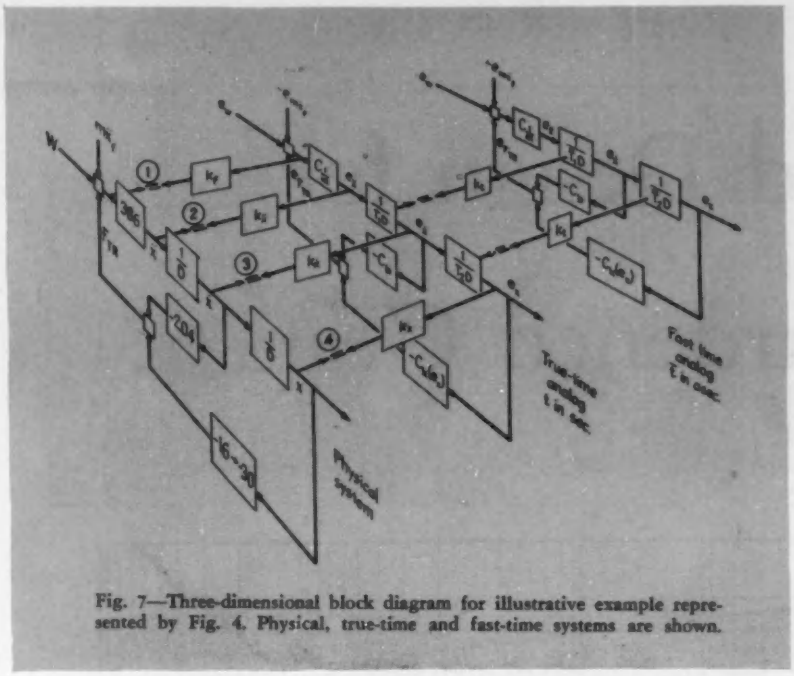


Fig. 7—Three-dimensional block diagram for illustrative example represented by Fig. 4. Physical, true-time and fast-time systems are shown.

in a unit lag should have the same numerical value in asec units and therefore be reduced accordingly.

In the cases where a desired time constant may not be set on an integrator, a convenient value may be set and thought of as the product of the desired time constant and a numerical coefficient. The introduction of this coefficient will merely change the actual setting of some series coefficient and possibly a local scale factor. Conversely, time constants integration and consequently time scale factors may be changed by introducing a numerical gain before each fixed time constant integrator. Of course, time lag time constants must be actually changed.

The time scale transformation which is concerned only with the time constants may also be indicated by operational blocks connecting the true-time block diagram in one plane with the fast or slow-time block diagram in a third parallel plane. This possibility has been indicated in the diagram for the numerical example which follows:

EXAMPLE:

A mass m is supported on a shock-mount structure having essentially constant damping but non-linear spring characteristics, Fig. 4. The frame is to be subjected to a time function, x_f (t), as recorded at an actual location. It is desired to perform an analog study which will yield solutions for the total force (F_{te}) transmitted across the shock-mount, (not including steady weight) as a function of time.

The data given below are the parameters to the example shown in Fig. 4. All the necessary information to set-up the problem on the computer is included.

Given data:

a) $m = \frac{1}{386} \frac{\text{lb sec}}{\text{in.}}$; ($W$ = 1 lb)

b) ζ (Damping Ratio) = 0.2;

$$\left(\zeta = \frac{b}{2\sqrt{Km}}\right)$$

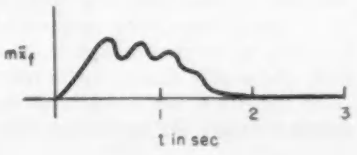
c) x_0 (static deflection) = $\frac{1}{16}$ in.

d) $b = 2.04\left[\frac{\text{lb sec}}{\text{in.}}\right]$;

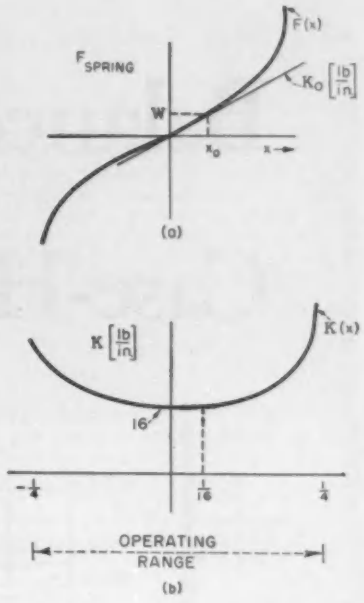
(Based on $K = 16\left[\frac{\text{lb}}{\text{in.}}\right]$ at x_0)

e) K = 16 to 30 $\left[\frac{\text{lb}}{\text{in.}}\right]$ (for the operating range)

f) Input:



g) Spring characteristics:



Letting $x_d = x + x_f$, then mx (acceleration) + cx (velocity) + $K(x)$ + $K(x_o)$ = mx_f (acceleration) + W, the functional block diagram for the system can now be drawn (Fig. 5).

The analogue block diagram for either "true-time" or "*asec*-time" is given in Fig. 6. Fig. 7 shows the three-dimensional block diagram for this system. Calculations for the true-time data are given in Table II.

There are, of course, many solutions depending on chosen values. Other information such as a predetermined scale factor (k_f) for an input function generator might lead to a different set of results.

Time Scaling For Fast-Time Analog

If the integrator being used may be set at 0.0004 and 0.004 [sec], it is convenient to let

$\overline{T}$ = 0.0004 sec and $\overline{T}_2$ = 0.004 sec.

Then, $k_t = \frac{0.0100}{0.0004}$ = 25 and

1 [*asec*] = 0.04 [sec] = 40 [millisec]

Thus, a square wave disturbance of 40 millisec divation corresponds to 1 sec in real time. In this example, the natural period of vibration is about $\frac{1}{20}$ sec. Thus about 20 cycles could appear on the analog display. This should be satisfactory for the given damping ratio.

Balanced Design for Case-Hardened Gears

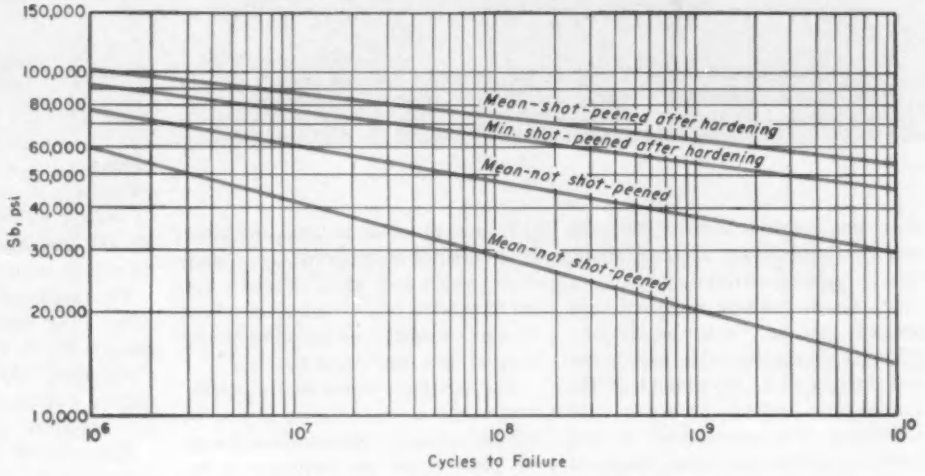


Fig. 1—Log-log plot of bending stress vs cycles to failure serves as S/N curve for gear teeth.

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THE DESIGN OF GEARS for power transmission, as treated by machine design texts and handbook data, provides no basis for estimating the life of the gears, or for selecting gear proportions for short life under extreme loads to meet requirements where minimum weight or space are more important than years of service. Almost every machine, however cheap, small, or light-weight, is expected to perform satisfactorily for some predetermined period of time; and hardly any manufacturer can afford to build 20,000 hour gears into a product having an expected life of 2,000 hours. Years ago this same problem was faced in the anti-friction bearing industry, and finally was solved by the application of statistical methods.

Conventional gear design methods generally consider both strength and wear. The strength of the tooth is determined by analyzing the tooth as a cantilever beam of parabolic shape, and evaluating the point of application of the load and the stress concentration at the root by one of the many methods that have been published. The beam stress thus determined is compared with the tensile strength for the chosen material. This provides a safety factor but does not indicate how many load cycles may be expected before the tooth breaks. If conventional fatigue curves are used for stress comparisons, the actual number of load cycles to failure does not agree with computed estimates.

Even if the beam stress could be computed accurately, and it cannot, the resulting stress value neglects the magnitude and direction of the residual stresses left in the tooth during its manufacture. These often exceed the applied stress, and the resultant stress is their algebraic sum. Since the fatigue chart is developed from data in which all residual stresses have been reduced to a minimum, it is obvious

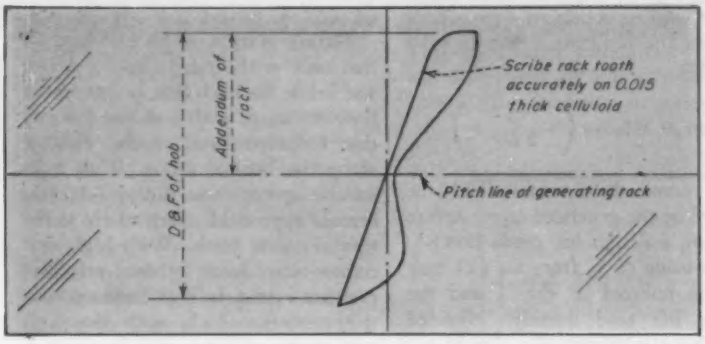
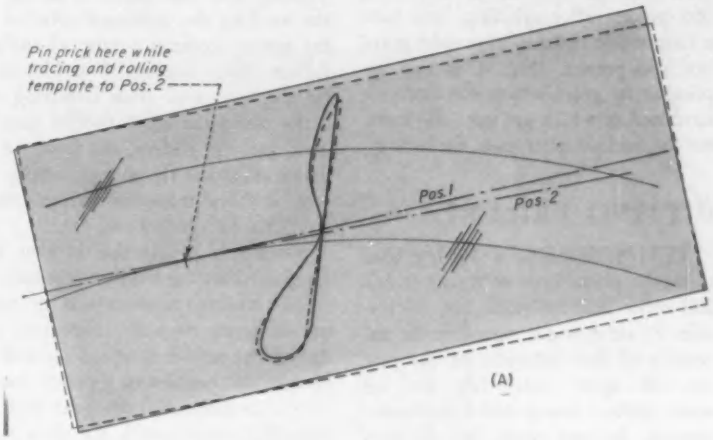


Fig. 2—Typical rack template constructed from thin celluloid or other transparent plastic is used for graphical determination of the X factor in the formula for bending stress of gear teeth, Eq (1). Cut-out shown is removed by scribing and then flexing the celluloid.



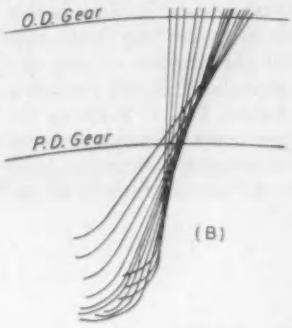


Fig. 3—Template described above is then used to generate tooth profiles as shown. Sketch in (A) illustrates two successive positions of such a generation. Sketch (B) is a completed profile of a typical spur gear tooth. Final step in determination of X factor is shown in Fig. 4.

why its use does not lead to accurate prediction of gear life.

The wear formulae are less satisfying mathematically, and, since they usually consider only one of the two modes of surface failure, are usually just as unsatisfactory.

Careful study of thousands of parts has led to the conviction that all gear tooth failures can be classified as: (1) Bending; (2) pitting; and (3) scoring. Any gear failure can be shown to be one, or a combination, of these. Abrasive wear is excepted, since it is considered as an oil seal failure.

Using statistical methods, the automobile industry has developed methods of analyzing gear design for each of these three types of failure. Stress factors have been established for each which will predict service in terms that agree closely with field statistics for automotive gears. These data also have been applied successfully to aircraft gearing for both piston and turbine engines, and the methods may be considered usable for nearly all applications of case hardened gears. They definitely are not applicable to thru-hardened or "cut-after-heat-treatment" gears. The preparation of similar procedures for this type of gearing is entirely feasible, but it can be done only after assembling complete data on hundreds of service failures.

If accumulated bending failure data are plotted in the form of Fig. 1, it may be considered as a S/N fatigue curve for gear teeth. A log-log plot is used because the prime objective is a finite life concept. It is emphasized that S_b as plotted represents actual stress multiplied by some factor, and cannot be expressed in pounds per square inch. Actual stress units are unnecessary, because all calculated stress values will be referred to Fig. 1 for endurance values.

S_b is computed as:

$$S_b = \frac{3\pi}{2}\left[\frac{W}{F \cdot Na \cdot X \cdot DP}\right] \qquad (1)$$

W is the tangential tooth load in pounds
F is gear face width in inches

Na is length of line of action with mating gear in inches
X is the factor determined from tooth layout
DP is the diametral pitch

This formula is used because it alone, of all those investigated, yields stress factors which produce straight-line plots for S_b versus the cycles to failure.

Accurate determination of the X factor can be made only from an enlarged-scale generated layout of the tooth itself. After selecting a convenient scale, say 10, the outline of the generating rack is carefully scribed to scale on a piece of 0.015 in. thick celluloid or transparent plastic, laying in the center-line of the rack tooth and the pitch line which will roll with the pitch circle of the gear. Carefully bending this template after scribing will permit removing the outline shown in Fig. 2. The pitch circle of the gear is now drawn to scale on a piece of vellum. Using a scriber to keep the template from slipping, the pitch line of the rack is rolled on this gear pitch circle, drawing in the rack tooth from the template in each succeeding position. This will produce a generated tooth, Fig. 3. Knowing the desired gear tooth thickness, the center-line of the tooth is drawn to scale, as is also the outside diameter of the gear.

DETERMINING X

Line AKB is normal to the tooth profile where the profile meets the outside diameter, Fig. 4. A series of lines is drawn through B through the profile at approximately equal intervals between the pitch diameter and the root diameter. Lines perpendicular to these rays are erected at the points where the rays intersect the tooth profile. These points are labeled $a, b, c, \ldots$ on the profile, and where the perpendiculars intersect the tooth center-line. Now, through these points on the profile are drawn perpendiculars to the center-line of the tooth. The points of intersection with the tooth center-line are designated a' (passing through a), b', c' etc. Carefully scaling the distances on the tooth centerline, $a\,a'$, $b\,b'$, $c\,c'$, etc., the minimum value is determined. This value, in inches, divided by the scale will equal the X factor. For small numbers of teeth this minimum value will occur where the ray drawn through B is tangent to the root fillet.

For preliminary design work, and where a standard spur tooth form is to be used, handbook tables of Y factors can be used to obtain an approximate value of the X factor, using the relationship:

$$X \text{ factor} = Y \text{ factor} \left(\frac{3}{2\,DP} \right)$$

Of course, these values should be checked by the generated layout before releasing a design for production.

The value of S_b from Eq (1) may now be referred to Fig. 1 and the fatigue life read directly. Nitrided gears have a fatigue life closely approximating that of gears shot-peened after lapping. Carefully ground teeth, shot-peened after grinding, will have a fatigue life equal to unground gears, not shot-peened. Fig. 1 is not applicable to gears which are not case hardened or which are not "file-hard" on the surface after case hardening.

PITTING FAILURES

This type of failure is closely related to similar phenomena occurring in ball and roller bearing races. Several theories [2] are in vogue regarding the mechanics of the formation of the pits, but all agree that they do not occur without heavy unit compressive stresses. In gear teeth, this form of failure makes itself evident by the appearance of dark crater-like depressions, usually at the pitch line. Failure is usually progressive, with small pits multiplying and forming larger pits until a substantial portion of the tooth profile has disappeared. The removal of the surface sometimes weakens the tooth enough to cause a bending failure, but the onset of pitting is properly considered a failure in itself, giving rise to noisy operation, contamination of the lubricant with particles from the pits, and generally requiring replacing of the gears.

Experimental work and field service have indicated that pitting is a fatigue phenomenon, but one having an extremely gradual slope if the S/N curve is plotted. For case-hardened spur and helical gears, it has been found statistically that pitting can usually be avoided if the compressive stress calculated at the point where the

SURFACE SCORING

tip of the gear tooth engages the flank of the pinion tooth is limited to 250,000 psi. This statement can be justified only when the tooth profile surfaces of the mating gears are file-hard.

Mating gears have pure rolling action only at the pitch circles. Above and below the pitch line, points on the profiles engage with a sliding velocity that is proportional to the distance along the line of action With high rotative speeds these sliding velocities become appreciable, particularly at the tips of coarse teeth. With high unit compressive loads, these velocities produce extremely high instantaneous temperatures, which, with the high unit pressures, may result in momentary welding of mating teeth. This welding and subsequent breaking of the weld by the continued rotation of the gears, produces a type of surface failure called scoring. It is identified by rough parallel lines occurring radially along the tooth profile, usually near the tip and/or the root. Evidence of actual fusion can usually be seen if the damaged teeth are examined under magnification.

Scoring is progressive in that the roughened surface tends to promote increased sliding friction which increases the tendency to heat. However, reducing the torque or speed sometimes permits the profiles to repolish themselves. Occasionally, the gear will be found in service with its teeth substantially reduced in thickness where alternate scoring and repolishing has occurred over a period of time. Destructive action of this kind may occur rapidly, and scoring, like pitting, is properly considered a failure in itself. For case-hardened, file-hard spur helical gears a scoring factor has been established as the product of the compressive stress at the tip of the tooth, the sliding velocity, and the distance along the line of action from the pitch-point to the tip of the tooth. It is commonly designated as the PVT factor.

To compute V and P at T points:

$$V = [(R_1 + T)\,R_g - (R_2 - T)\,R_p] \times \left[\frac{V_p}{(R_p)\,(R_g)} \right]$$

$$P = 2290 \times \sqrt{\frac{(W)\,(C \sin\alpha)}{(F)\,(C_r \cos\phi}} \left[\frac{1}{(R_1 + T)\,(R_2 - T)} \right]$$

where

R_p = pitch radius pinion, in.
R_g = pitch radius gear, in.
ϕ = pressure angle, plane of rotation
α = normal pressure angle
T = distance along line of action, in.
R_1 = $R_p \sin \phi$
R_2 = $R_g \sin \phi$
W = tangential driving pressure, lb
C = center distance, in.
F = face width, in.
C_r = contact ratio
V_p = pitch line velocity, ft per sec

Fig. 5 shows graphically how this *PVT* factor can be plotted for various points along the line of action. If this value is limited to 1.5 x 10^6, failures do not generally occur with ordinary mineral oils. Higher values may be tolerated with EP lubricants; these contain compounds which react chemically with the tooth material producing a surface that is resistant to any kind of welding. As this surface is eroded by wear the presence of the EP compound continually renews it. In machinery where it is not feasible to use this type of lubricant, the gears can be coated by phosphide of molybdenum treatments which have the same anti-welding effect until the coatings are worn away. This has proved particularly effective for drives that are less susceptible to scoring after the break in period.

BALANCED DESIGN

With the acceptance of the three basic modes of gear tooth failure, it becomes possible to design gears equally resistant to bending, pitting, and scoring. In Fig. 5, the two vertical lines have been drawn to represent the extremes of the line of action of the mating gears. Note that these pass through the scoring factor curve

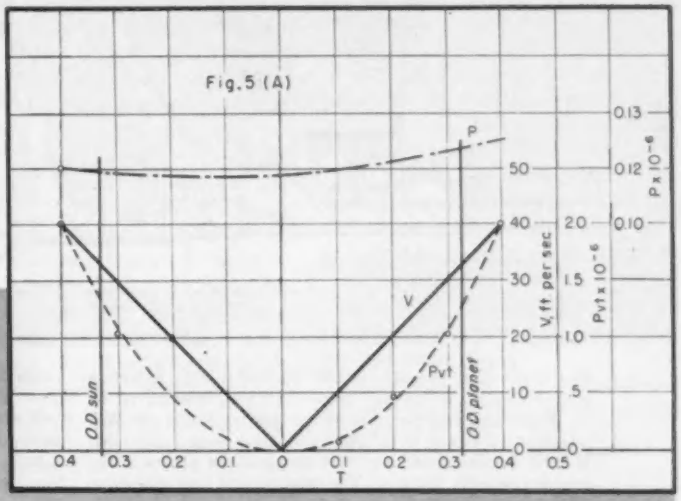


Fig. 4—The minimum value of the family of lines *aa'*, *bb'*, *cc'*, etc. is the *X* value. For most purposes, a drawing 10-times-size is adequate, but for fine pitch calculations, a scale of 50- or 100-to-one may be required.

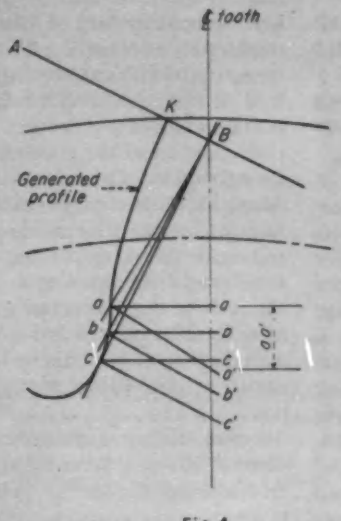


Fig. 4

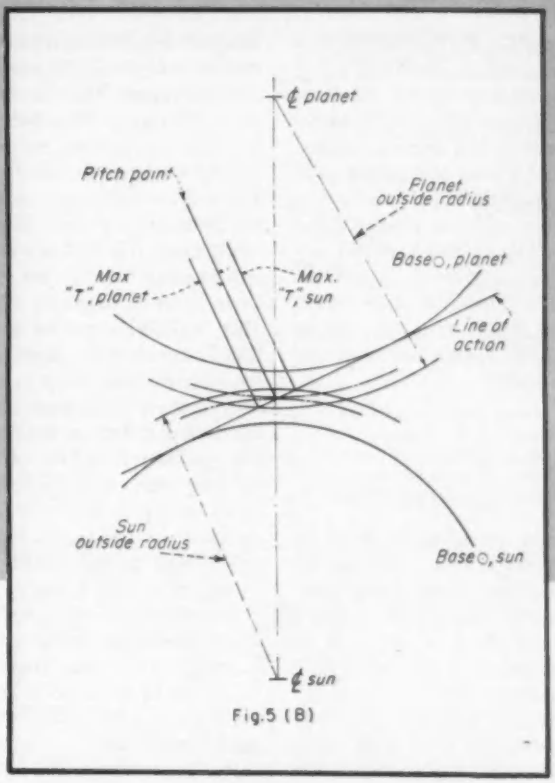


Fig. 5—PVT chart for determining OD of pinion and gear to prevent scoring. With mineral oils, scoring is usually avoided if the PVT factor is 1.5 x 10^6 or less. Values are for the sun-planet mesh of the unit illustrated in Fig. 6. Sketch in (B) shows how to scale pitch point to tooth tip distance.

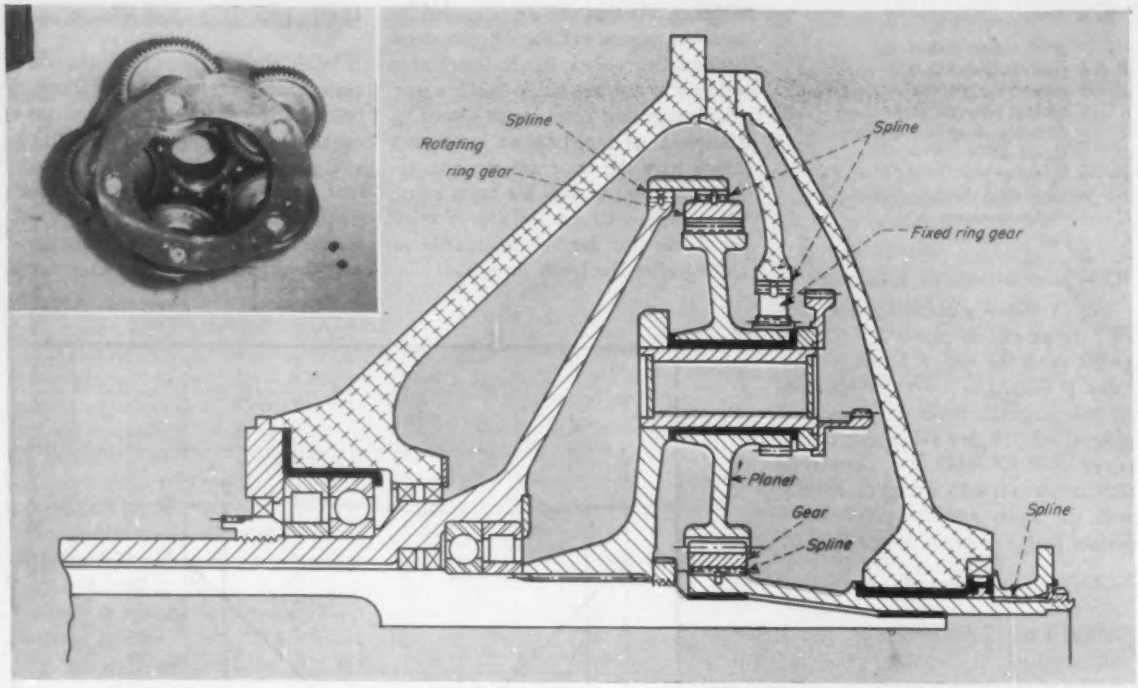


Fig. 6—Section through 10,000 hp turbo-prop reduction gear. Propeller shafts are counter rotating, one driven by the planet cage and the other by the rotating ring gear. Each planet has a PD of 9 in. and carries more than 2,000 hp. The 7.5 in. sun rotates at 7.088 rpm and the planet spider at approximately 910 rpm. The rotating ring gear (meshing with the OD of the planets) in the same plane as the sun gear also turns at 910 rpm but in the opposite direction. All gears are file hard, case hardened steel corresponding approximately to SAE 3310. Total weight of finished unit is 1,200 lb, including propeller shafts and accessory drive gears and pads. Nest of planet gears is shown in insert.

at equal values of PVT. The length of the line of action itself was chosen to give a contact ratio of 1.5, which by experience is known to be adequate for the particular service being considered. The value of T thus determined establishes the outside diameters for the mating gears, with the corresponding values of P (compressive stress) less than the limiting value of 250,000. By the use of the bending stress factor, Eq (1), a diametral pitch can be chosen that will operate for the desired number of cycles.

IMPORTANCE OF ELASTICITY

All of the preceding is based on the assumption that no distortion occurs under load which would upset the uniform distribution of load along the face width of the gear teeth. With elastic materials this can occur only at one condition of load, with elastic deformation tending to make the shafts and/or mating teeth slightly non-parallel at all other load values. If the designer begins his layout with this fact in mind, he may utilize the deflections of various items in the assembly in such a manner that one will offset the other, or, in fact, compensate for minor errors in machining accuracy. Fig. 6 shows a planetary unit in which the rotating ring gear deforms elastically under full load in a radial direction by about 0.010 inches at the point where it is contacted by each planet. This flexibility serves to equalize the load between the planets, since a tendency for one planet to carry more than its share of the load would result in a greater deflection, tending to move that particular planet out of mesh with the ring gear. Longitudinal elasticity of the ring gear section tends to load the center of the tooth face more intensely than the ends, these deforming radially away from the contacting teeth of the planets. Careful study of controlled elasticity in the design of highly loaded gears has been responsible for the successful operation of light-weight machines in applications where more rigid drives failed.

Strict adherence to the formulae for gear design may lead to face widths considerably in excess of good practice. Because of the difficulty in distributing load along the length of a long tooth, the face width should never exceed the pitch diameter of the pinion for case-hardened gears. Crowning, that is reducing the thickness at the ends of the face, may be useful for avoiding tooth-end-contact on long pinions, and in some specialized drives that lead of the teeth of the pinion and gear may be deliberately mis-matched at no-load with the purpose of obtaining full face contact at some higher torque condition.

Before making such an important decision, however, the engineer should do developmental testing under load to determine the amount of permissible mis-match. The engineer may use careful calculations of tooth deflections as a guide, but obviously he cannot take all of the factors that influence design variables into consideration with sufficient accuracy and then predict by theoretical analysis the actual deformation of a gear tooth under a dynamic load.

HEAT-TREATMENT

Almost any machinist can be trained to cut accurate gears on modern manufacturing equipment, but hardening gears seem to be more of an art than a science. Whether the parts are to be finished by lapping or by grinding, it is necessary to bring them through heat-treatment involving radical temperature changes of hundreds of degrees with total distortions of only a few thousandths. This usually requires quenching in fixtures, the design of which must be developed by trial and error methods. The designer can simplify this effort and reduce cost by avoiding gears of complex section, and by studying the behavior of various shapes of gears during the development of quenching methods. Since this process is an art, considerable experience is the best design criterion.

Nitriding, although less sensitive to distortion, produces a hard case by long exposure of the part to an ammonia atmosphere at about 1000 F. This is much like a stress-relieving process, so it is necessary to keep the parts as stress-free as possible during the operations preceding nitriding to avoid distortion.

The purpose of case-hardening is dual to produce a hard wear-resistant surface, and to produce the maximum strength. Case hardening strengthens a part both by the addition of an intensely strong outer layer and by producing favorable residual stresses. Gears, properly carburized and hardened, or nitrided, have teeth with their surfaces heavily pre-stressed in compression. This pre-stressed surface condition has been shown [3] to be helpful in prolonging fatigue life.

The selection of materials for carburized gears is largely a matter of metallurgical and manufacturing convenience, since nearly all case-hardening materials perform equally well in service when properly processed. Because the load is carried by the case, the core properties are relatively unimportant except as they influence the hardness and residual stress conditions of the case. [4] With extremely shallow cases, it is obvious that the core must have sufficient hardness to prevent fractures under compressive loads similar to the failure of thin ice to support heavy weights. Case depth should be sufficient to contain the depth of maximum shear, but not more than $\frac{1}{3}$ of the tooth thickness at the pitch line should be case. Excessive case depths may cause internal fractures near the junction with the core, since the core must supply the tension to offset the high compressive stresses in the case. When these tensile stresses exceed the strength of the core material a crack forms, and failure may occur in a few revolutions. The tips and ends of the teeth are particularly vulnerable since the carbon penetration here is from three directions, and special care must be taken with teeth which have extremely narrow lands at the tip as is often the case with long addendum pinions. Fig. 7(A) shows how the core may become pointed, thereby concentrating the total tension over a very small area and increasing the unit stress to a value exceeding that of the core material.

In Fig. 7(B) is shown a photomicrograph of an internal fracture in another tooth of the same gear. Note that the fracture does not penetrate the carburized case on either side of the tooth. This evidence points up a source of failure.

COST CONSIDERATIONS

Any cost advantages to be obtained in comparing a transmission designed for case-hardened gears with one for non-case-hardened gears must be related to the smaller size, lighter weight, and greater reliability of the case-hardened gears. This is particularly true since several manufacturing operations are involved in going to case-hardening, plus the requirements of tooling and developmental work in heat-treating. For one-off or small lot production this almost always makes the case-hardened gear drive more expensive unless weight or space itself is costly as in the case of aircraft or automotive units.

For quantity production, these added operations can be offset by the reduction in material and machining time permitted by the smaller case-hardened gears, and the reduction in pitch diameter may be sufficient to reduce pitchline speeds enough to require less accurate toothspacing.

The reliability of case-hardened makes them attractive in applications where maintenance is uncertain.

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(3) Fatigue Failures are Tensile Failures, J. O. Almen, *Product Engineering*, March, 1951.

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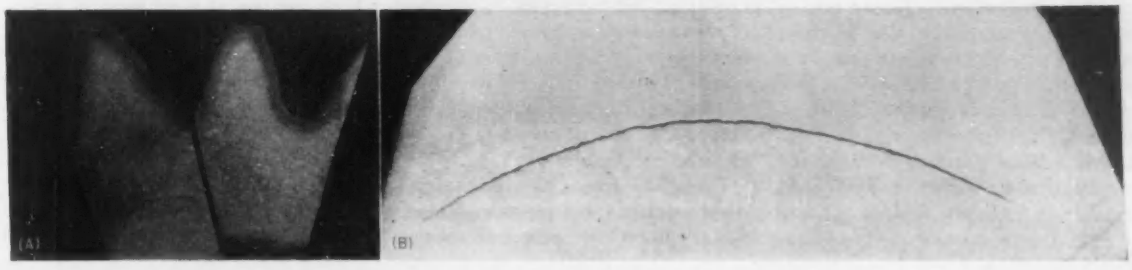
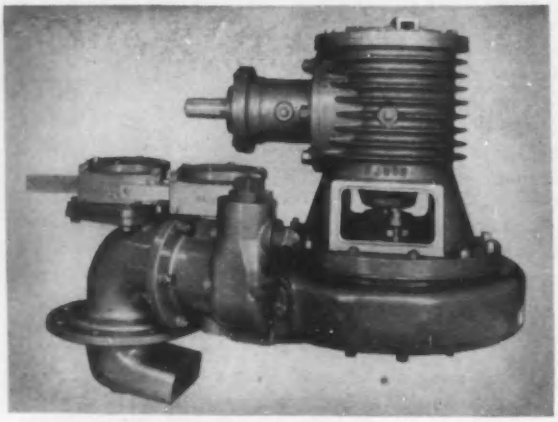
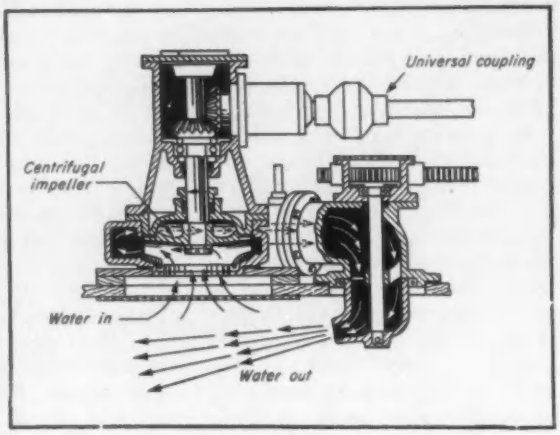
Fig. 7—(A) Gear tooth at left shows how excessive depth of case reduces core nearly to sharp point at tip of tooth. Properly carburized tooth, right, shows blunt core well proportioned for carrying internal stresses (four times size). (B) Section through tip of another tooth of gear in (A) left. Concentration of residual tension stresses in tip of core has caused ultimate strength of core material to be exceeded, causing internal fracture. Although this gear carried over 1,000 hp for several hours, this internal fracture did not penetrate the outer case material of the tooth.



TECHNICAL NEWS





NEW MARINE PROPULSION UNIT uses centrifugal pump to draw water in and then force it out through a small jet nozzle.

Hydrojet Powers Small Craft

A MARINE PROPULSION UNIT in which a jet of water both powers and steers the craft went into production last month at the Kermath Manufacturing Company. Announced publically over a year ago, the design—called Hydrojet—has been undergoing tests ever since. Now Kermath is offering the unit to small boat builders.

In the new power plant, there are two main components: a 61 hp gasoline engine that weighs 400 lb, and the 100 lb hydraulic unit.

Water is sucked through an intake grille in the hull, put under pressure by a centrifugal pump, and then discharged at a rate of 1,100 gpm through a small jet nozzle. The action propels the boat forward. Steering is accomplished by positioning the direction of thrust of the nozzle, which can swivel through a full 360 degrees.

Because the jet trails only 3½ in. below the hull, boats equipped with such a propulsion unit can navigate in quite shallow water. Chances of running aground or fouling in nets or weeds are reduced, since the depth of water needed under the boat is as little as one-third what a conventional propeller-driven craft requires. And, if the boat does run aground, the jet nozzle can be reversed so that the stream of water washes mud and sand away from under the hull.

Hydrojet can operate in silt or sand-laden waters up to 60 percent solids. The screened water intake can be cleaned automatically by putting the controls in neutral and gunning the motor; the resultant back-flush sweeps out all sediment and cleans the intake grille.

The nozzle takes the place of conventional screw, shaft and rudder. Hydrojet boats are slower—attaining speeds up to 80 percent as high as propeller-driven craft using standard marine engines of equivalent horsepower rating. But they can turn in about one-third the radius required by the conventional craft.

As a starter, the company recommends using the gasoline unit on fishing, fire-fighting, pleasure and commercial shallow-water craft. (A diesel-powered-Hydrojet tug has been built and tested in Oregon. The craft will be used to tow logs on a river whose bottom and shallow depth have damaged conventional craft). The next step will be putting a diesel-powered unit, capable of bigger outputs, into production.

Society Survey: How to Hold Engineers

HOW TO ATTRACT AND HOLD ENGINEERING TALENT is the title of a research survey recently completed by the Professional Engineers Conference Board for Industry in cooperation with the National Society of Professional Engineers. It's number three in a series of reports aimed at spreading information about engineer-management relations. (Number two: "How to Improve the Utilization of Engineering Manpower" was described in *Product Engineering*, January 1953, p. 197).

Executives from 200 companies—which operate 1,428 plants employing almost 1,000,000 people—answered the group's questionnaire. Also interviewed were 1,300 engineer-employees working in all fields of engineering activity. The answers supply a cross-section of thinking on a variety of items of interest to technical personnel. These are typical highlights:

On Engineering Training: Most employers would like to see an improvement in engineering curricula presently taught at college and universities. The change: more courses in the humanities. Executives indicated that, in their opinion, scientific training was at a high level, but new-

comers to engineering were deficient in other areas of study particularly English, the social sciences and business administration.

Other suggestions include raising morale of engineering employees and stimulating their professional growth and contentment by encouraging such activities as participation in professional organizations and community affairs, writing for publication, lecturing and teaching.

On Recruiting Techniques: Everybody seemed to think that recruiting techniques need a good overhauling. In the hectic struggle for engineers, companies have resorted to cut-throat competition, overselling the graduate with a false picture of his potential job and the company, and offering spectacular bonuses and gifts. Although such practices often get temporary results, graduates obtained that way rarely stay more than a few months.

On Unions: Traditionally, the engineer regards himself as a professional; he is impatient of regimentation, wants to stand on his own feet and grow professionally. So, the results of this survey will probably surprise some sections of management. Thirty-four percent of answering engineers said they believed that engineers' interests would be strengthened economically or otherwise by membership in a collective bargaining organization. Although 66 percent of the engineer questionnaires indicated no interest in union membership and most executives saw no attempt at organizing in their engineering departments, the report included this warning:

". . . There has been an alarming increase in the number of engineers who have so far deserted accepted professional standards as to consider unionization (for themselves) in a favorable light . . . This trend could easily snowball into an unpleasant actuality, particularly in the event of business recession, and it serves as a clear warning that the professional societies and industry must take immediate steps to forestall the all-to-easy descent from professionalism to trade unionism."

Copies of the survey are available from National Society of Professional Engineers, 1121 Fifteenth St., Northwest, Washington, D. C. Price: $2.00 per copy.

Germans Form Research Group

BONN—Government agencies and private industry are financing a new research institute that will specialize in the study of plastics. The new group, called Research Association for Plastics, will spend $296,000 over the next three years to build facilities.

Heading the study group is the former professor of technical physics at Darmstadt's Technical High School, Professor Dr. Hellwage. He will supervise the work of the twelve scientists and 25 technicians who will make up the institute staff. Yearly operating budget is expected to top $100,000, once construction is completed.

Develop Titanium Bolts

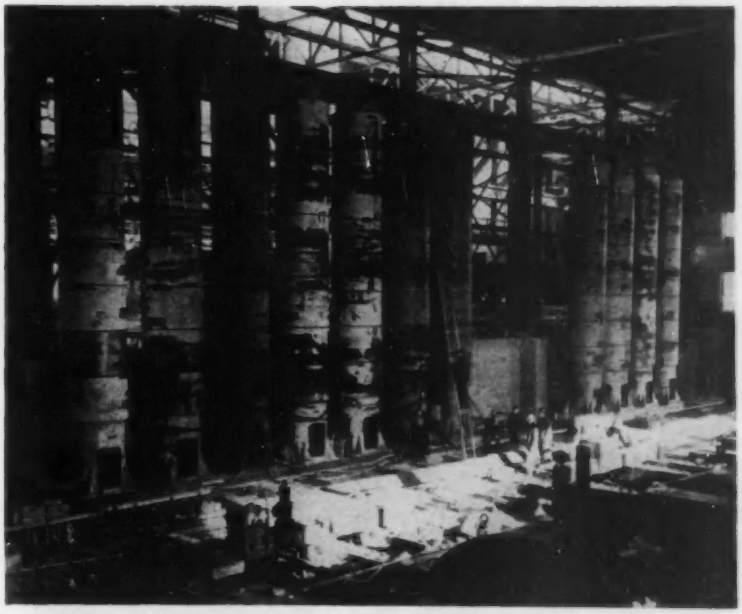
LIGHTWEIGHT-WEIGHT, high-strength titanium bolts of six types, for use in airframe and aircraft engines, have been developed by the Standard Pressed Steel Co., Jenkintown, Pa. The company, big producer of socket head screws, says that it can now produce bolts of titanium in virtually any design and size to order.

The new bolts announced by SPS are in two lines of flush head shear bolts, two lines of internal wrenching tension bolts, a line of external hexagon shear bolts, and one of external wrenching tension bolts. Sizes are No. 10, $\frac{1}{4}$, $\frac{5}{16}$, $\frac{3}{8}$, $\frac{7}{16}$, $\frac{1}{2}$ and $\frac{5}{8}$ in.

College To Build Reactor

PENNSYLVANIA STATE COLLEGE is the second university to own a nuclear reactor (the first: University of North Carolina whose unit started operations last September). Last month the Atomic Energy Commission announced that it had authorized the allocation of fissionable material to fuel the college's proposed low-power reactor.

To be constructed for an estimated $250,000 to $300,000, Penn State's reactor will operate at a power level of 100 kilowatts. It will be cooled and moderated with ordinary water and will use enriched fuel that is suspended in a pool of water to serve as a shield against radiation.



USAF HEAVY PRESS installation at Wyman-Gordon Company is nearing completion, as indicated by the state of this new hydraulic accumulator station—the world's largest. Seven pumps totaling 10,500 hp will charge the eleven giant steel bottles with water at a pressure of 4,500 psi required for the 50,000 and 35,000 ton die forging presses designed and being built by Loewy-Hydropress to form aluminum aircraft parts.

Atomic Batteries—a New Source of Power

TO MOST ENGINEERS, converting nuclear energy into useable electricity means replacing an oil- or coal-fired boiler with a nuclear reactor that generates steam for conventional turbine-generator sets. That approach scored the first successes: lighting an Idaho laboratory of the Atomic Energy Commission, powering the atomic submarine Nautilus, and laying the groundwork for the first atomic central station. But scientists have been exploring an even more dramatic possibility —direct conversion of radioactivity into an electric current.

Last month, laboratory men were able to add a new expression to American vocabulary with the term "atomic battery." And they had two different kinds of units to prove direct conversion is practical: the Ohmart gas cell and the RCA crystal battery.

High Speed Ionization

Both devices depend on phenomena that are well known to physicists. When a high speed particle emitted by a radioactive source moves through a medium, the charged particule ionizes the material. So, bombardment of a gas, liquid or solid produces large numbers of slow-speed free electrons, the kind that constitute an electric current when they move along a wire.

Phillip E. Ohmart, President of the Ohmart Corporation, was one of the first scientists to realize the current generating possibilities of radioactive ionization. He built a cell (*Product Engineering*, July 1953, p. 7) that had two electrodes made of materials widely separated on the electromotive scale (lead and gold), filled the cell with air, and then exposed it to radiation. Slow speed electrons, formed by collision with emitted particles, moved to the anode, while the remaining positively charged ions drifted towards the cathode. That produced enough action to register on a laboratory galvanometer.

Since that first success, Ohmart has been able to incorporate several improvements in the cell. For instance, Acheson Colloids' Aquadag was found to be more positive than gold and has replaced the noble metal as the anode. And different gases have replaced air as the ion source.

Ohmart has already built about 125 atomic cells. They are being used to power a variety of delicate instruments. Their chief advantage: constant voltage and amperage for very long periods of time. (One cell has an estimated life of 20,000 years. Life depends on the kind of radioactive material used.) Power output of a typical cell is about 10 millionths of a watt—10 microamps at one volt, and laboratory models have reached as high as 2½ volt potential.

INVENTOR OHMART and his gas atomic cell.

The Crystal Battery

Scientists at the Radio Corporation of America modified Ohmart's fundamental idea, using their background in solid state physics and electronics. In the RCA miniature atomic battery, a high speed electron emitted by a radioactive source smashes into a thin wafer of semi-conducting material, releasing a shower of 200,000 slow speed electrons.

By using a solid, RCA has been able to decrease the size of the unit. The experimental model consists of a radioactive source (Strontium-90) coupled to a wafer of semi-conducting silicon. An impurity material is alloyed into the crystal to form a junction similar electrically to that found in a junction transistor, but considerably larger in area.

Strontium-90 was selected because it is a highly active source of high speed electrons (or Beta particles), it is one of the most abundant materials resulting from fission of uranium in a reactor, and it is long-lived—its half life is roughly 20 years, meaning its radioactivity dissipates by 50 percent every twenty years.

In reviewing past experiments in the field, Dr. E. W. Engstrom, RCA's vice president in charge of research laboratories, pointed out that the new atomic batteries produced electricity a hundred times more efficiently than any other type of generator. RCA's indefatigable Chairman of the Board, Brig. Gen. David Sarnoff said:

"This development, though still in a pioneer stage, may prove to be the beginning of a new chapter in man's efforts to use some of the enormous untapped energies within the nucleus of the atom for peaceful purposes."

For the Future

And the General predicted that the battery was likely to be first applied to miniature devices such as portable

and pocket-sized radio receivers, hearing aids, signal controls and similar devices.

Ohmart pointed out some of the difficulties that remain to be solved. For instance, power output of a cell is, of course, limited by the amount of radioactive material used—approximately on the basis of one curie producing six milliwatts. To obtain electricity in quantities useable for industry or home consumption, great quantities of radioactive material are needed. Ohmart's idea: put the cells into nuclear reactors, or around reactors to use stray radiation.

Another problem—specifically for the RCA unit—is the effect continued radiation will have on the crystal. Most substances are damaged by bombarding electrons.

Hot Forming With Glass Lubricant

A NEW PRODUCTION PROCESS that combines the advantages of hot forging with those of cold extrusion makes possible hot forming cylindrical shapes in all forgeable materials. Key to the Scaife technique, which is a modification of the Ugine-Sejournet tube extrusion process, is the use of glass as a lubricant.

After a billet is heated to extrusion temperature, glass powder or woven fiber is applied and the billet positioned in a press. The extrusion is completed with the glass acting as a viscous lubricant between the die, punch and workpiece. (In hot forging, the limitation is dimensional control, even though the process can deform material drastically in a single press operation; cold extrusion, on the other hand, permits close dimensional control but needs several operations).

Apparently, glass reduces extrusion pressure and extends the life of the die. Other advantages: improved surface conditions minimizing subsequent machining and high extrusion ratio (size of original slug to size of finished piece).

Patent rights on the process are held by a French firm, Comptoir Industriel D'Etirage et Profilage de Metaux, Societe Anoyme. In the United States, Scaife Development Company, a subsidiary of the Scaife Company, is the exclusive licensing agent.

Foreign News Report

• Australian plastics fabricator Laminex Pty., Ltd., claims it is producing the largest high pressure laminated sheet in the world—12 ft by 4 ft. They use pressure equivalent to 3,000 tons to form this sheet, which is said to be cheaper than veneers.

• At the recent Turin (Italy) Exhibition of Plastics, visitors examined a new shiny-surface protective paint—Vitrorit—based on colored vinyl resins. Made by the Edilma Company, the new coating protects against fire, water, ink, and acids.

• Shortages and high prices of gasoline in Great Britain have encouraged British Automobile manufacturers to experiment with Diesel-engine passenger cars, following the lead of German Mercedes, Italian Fiat and Dutch Joymaster. At the recent Earls' Court Motor Show F. Perkins, Ltd., displayed three new diesel engines particularly designed for passenger cars. The big advantage: Diesel oil, costing 10 percent less than gasoline in Great Britain, will supply twice the mileage.

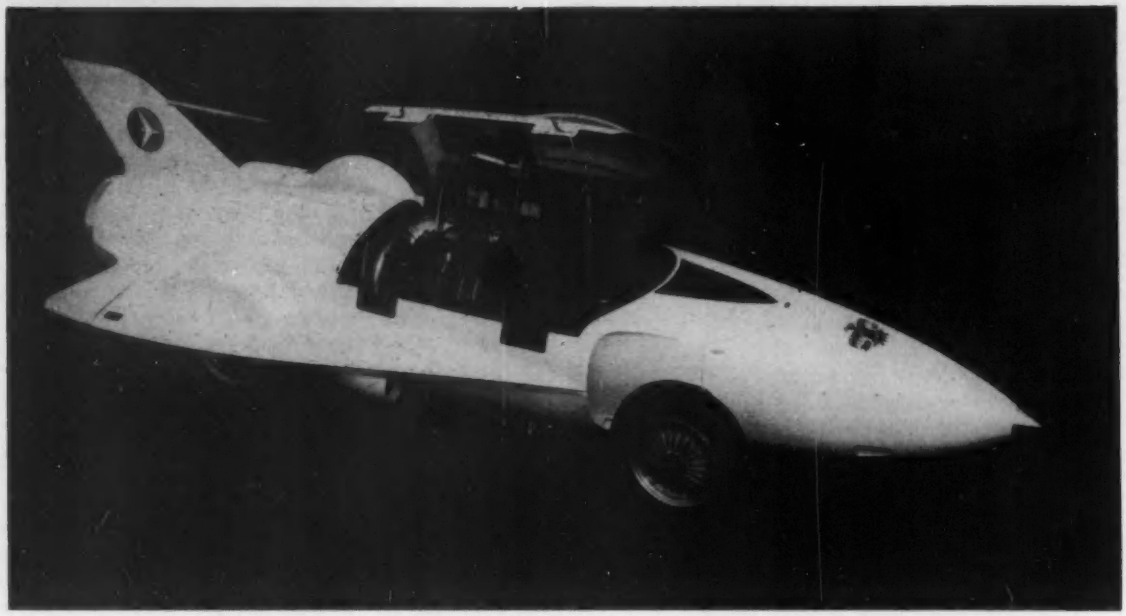
• British specialists who toured the U. S. last year under the auspices of the Anglo-American Council on Productivity and the Mutual Security Agency have completed their report on how Great Britain can better utilize available parts and materials. The team's main recommendations: design policy should be determined at the top and then made known to all members of the organization concerned in its application; project engineers should supervise the transfer of a new design from research through engineering to production; co-ordination between design and manufacturing engineering should begin in the design-drafting stage to consider economy of scarce materials and to uncover alternatives.

• Moscow newspapers are carrying advertisements offering Russia's most modern automobile, the Zim, for sale to individual purchasers in the Soviet Union. The sleek, streamlined, six-passenger limousine is equipped with a 90 hp engine, has a top speed of 75 mph, and carries a king-sized price tag—about $10,000.

• AUSTRALIA, with unusually heavy titanium ore deposits, plans to exploit the increasing demand for this metal. Zinc Corporation, Ltd., has joined forces with the Commonwealth Scientific and Industrial Research Organization in a study program at Melbourne University.

ITALIAN EXPRESS

New Italian Diesel train incorporates many recent innovations. Designed and built by Fiat (better known as an auto manufacturer) the usual size for commuter or long hauls is a three car train—a trailer car sandwiched between two power cars. In each power car, a 505 hp, 12 horizontal cylinder diesel supplies the driving force. Trailer car contains seating capacity for 64 passengers, two washrooms, a bar and a kitchen. Fiat is building 20 such trains for the Spanish National System and three for the Portuguese Railway Company.

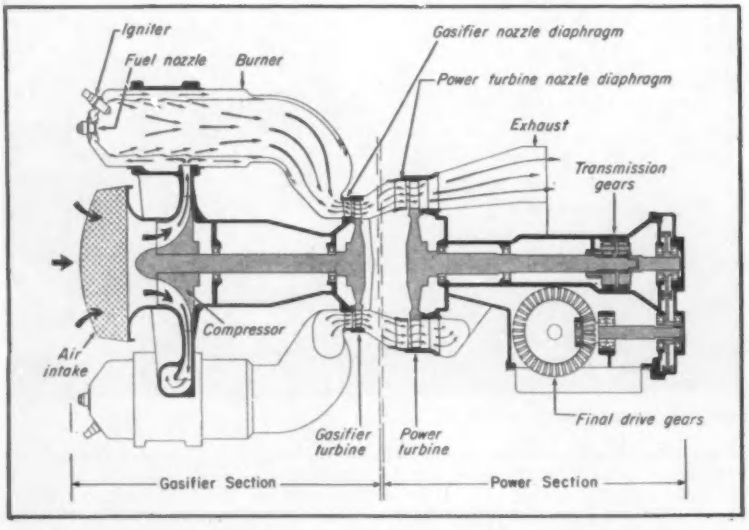


AERODYNAMICALLY STYLED, General Motor's Firebird will serve as a laboratory on wheels to explore the possibilities of gas turbine power for automobiles. In Europe, at least two manufacturers have been running secret trials on such cars.

GM Shows Turbine Powered Car

WHEN GENERAL MOTORS CORPORATION opened Motorama, the company made an announcement that confirmed what many auto people had long suspected: GM was studying a gas turbine powered, experimental automobile and would evaluate the performance of such a unit for automotive applications. Called the XP-21 Firebird, the sleek single seater looks like a racing car, but it is one model that excites interest because of its innards rather than its exterior styling.

Mounted right on the frame in the rear is the power package, a 370 hp gas turbine, over five feet long and weighing 774 lb. The unit is divided into two parts (see sketch below): (1) a gasifier section with a single stage air compressor ($3\frac{1}{2}$ to one pressure ratio), twin combustion chambers, single stage axial flow turbine and engine accessories, and (2) a power section containing a single stage axial flow turbine, a transmission and a final drive unit.



CROSS SECTION of turbine shows flow of gases through significant parts from air intake to exhaust. Engine has torque converter characteristics—using a gas coupling.

In the gasifier section, compressed air supports the continuous burning of kerosene in twin combustion chambers. From these burners the gases move into a gasifier nozzle ring that accelerates and directs them against the curved blades of the first turbine. Power extracted here operates the air compressor.

Next, exhaust gases from the gasifier turbine enter the power section and impinge on the power turbine wheel to drive the transmission.

Basically, compared to a conventional engine with a torque converter transmission, the gasifier section replaces the engine and torque converter pump; the power section takes the place of the troque converter turbine, transmission and rear axle gears.

In preliminary testing, GM engineers have discovered that gas turbine power introduces a flock of new problems. For instance, the gasifier turbine operates at 26,000 rpm, the

power turbine at 13,000 rpm—that means high speed bearing problems and high centrifugal stresses. Another difficulty is the rate of fuel consumption. Test drivers can empty the 35 gal tank in an hour.

So, GM spokesmen aren't predicting a switch to turbine powered automobiles, even in the relatively distant future. But they do think this type of power plant has possibilities for express trucks and buses that carry heavy loads over long distances.

Silicon Transistors for High Temperature

RIGHT AFTER the first transistors performed satisfactorily, the electronics industry began looking for a substitute to replace germanium, the semi-conducting metal used in such devices. Reason: the material loses its transistor properties at relatively low temperatures. Last month, Philco Corporation announced that they had finally succeeded in producing a useable germanium-free transistor. By infusing indium salts into opposite sides of a silicon slab, Philco made a unit that promises better high temperature characteristics than have been attainable with germanium devices.

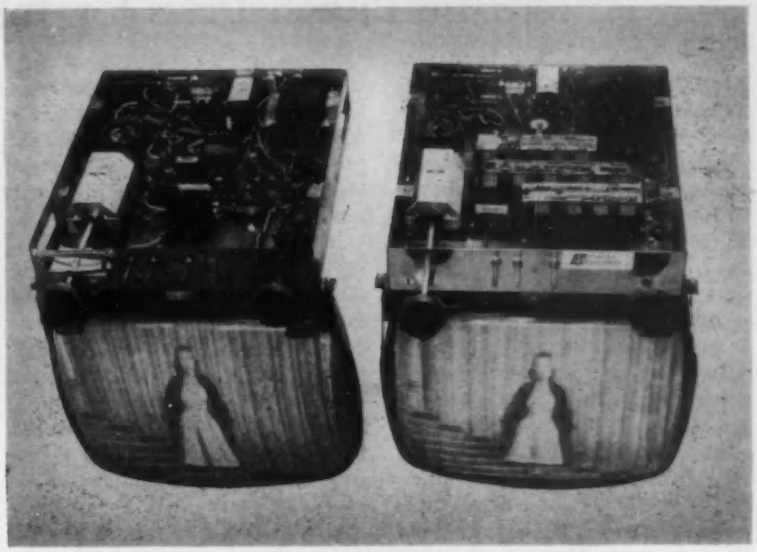
To researchers, silicon was an obvious replacement for germanium. It has many similar properties and good high temperature characteristics. But it is exceedingly difficult to obtain in the pure form required for transistor action and it's been reluctant to perform according to theory.

Last December, significant progress was made when Philco reported a new technique for making germanium transistors, a method the company labeled the "surface barrier" technique. It was this approach that produced the silicon transistor.

The new process involves directing two tiny streams of liquid idium salt at opposite sides of a tiny slab of silicon while an electric current passes through the streams and etches away the silicon. This erosion continues until the tiny jets almost drill through the slab, then the current is suddenly reversed. That stops the etching and electroplates out indium.

Even more recently, at Raytheon Manufacturing Company, engineers have also been putting silicon transistors through their paces. The results: satisfactory performance at temperatures up to 350 F.

Still, silicon transistors are a long way from commercial availability. Most important, there is no process capable of turning out reasonably large quantities of pure material. And there are some technical problems too. But, optimistic Philco and Raytheon officials predict that there will be a satisfactory supply of silicon when all the other difficulties are solved.



MODULAR DESIGN of television set components (right) compared to conventional construction. Sanders Associates predicts significant manufacturing savings.

Modular Electronics Continues To Grow

PROJECT TINKERTOY, National Bureau of Standards' program for the mechanized production of electronic components announced in September, (*Product Engineering*, October 1953, p. 206, December 1953, p. 134) was still making news last month.

- Item: American Car and Foundry Company entered the electronics field with a new division—ACF Electronics. The first project: development of improved Tinkertoy production machines that are cheaper and more efficient.
- Item: Sanders Associates, New England electronic research specialists, unveiled a television receiver using the modular design concept of Project Tinkertoy. The significance: it is the first commercial adaptation.
- Item: In Washington, Academy of Sciences presented its annual engineering award to Robert L. Henry, director of Project Tinkertoy at NBS, as recognition of his work in the development of machine-made circuitry.

ACF's new division has set up shop in Alexandria, Virginia, headed by J. Gilman Reid, Jr., who recently resigned as Chief of NBS electronics division. Several other NBS electronic specialists will join Reid in a gradual exit so as not to disrupt programs already underway at the Bureau. These men intend to make radical changes in Project Tinkertoy production equipment. ACF's first interest centers on these machines, leaving the production of ceramic wafers used in the system to two outside companies.

Just what the modular design may mean to industry is demonstrated by the Sanders Television set (see cut above). The clean look of the set is incidental; the big factor is the reduction of hand production operations. For example, in the conventional set there are almost 600 hand-soldered connections; in the new receiver, this maze is replaced by three compact packages that plug into the chassis.

Automatic Punch Press for Job Shop Duty

AN AUTOMATIC PUNCH PRESS with an electronic brain and hydro-pneumatic muscles is the latest automation project to bear fruit. Hailed by its developers at the Electronics Laboratory of the General Electric Company as the first machine tool capable of locating position accurately and automatically, the press stamps holes out of sheet metal in a variety of sizes and at rates up to 30 per minute.

But the big significance of this development is not in the production capabilities of the equipment—it's what the machine portends. GE scientists developed the automatic punch press as a by-product of a Signal Corps research program. Main objective of the program: to develop machinery to assemble and test electronic circuit subassemblies for military gear—automatically. The aims of the research are similar to what's been accomplished in Project Tinkertoy (see page 213) by U. S. Navy and National Bureau of Standards people. The approach, however, is different.

According to Signal Corps philosophy, electronic subassemblies should be made up of standard components (Tinkertoy equipment makes its own). Heart of the system is a sheet with a main printed circuit. The equipment is built up as the components—resistors, capacitors, etc.—are automatically placed on the circuit and soldered. At present, even the best estimates put final completion of such machinery several months away.

Biggest stumbling block was devising a method of accurately locating the position at which components were to be placed. That's where GE concentrated their research. The automatic punch press is a practical application of the results of this study.

To determine the size, number and location of holes, an electronic digital computer reads input information impressed on a plastic sheet and transmits instructions to the rotating turret head and to the high-torque, hydro-pneumatic servo system that positions the table within ±0.001 in. of position.

In operation, when the turret receives a signal, it rotates until the proper size punch is moved to stamping position; at the same time, the servo system moves the table along with the workpiece under the punch.

Recently the company moved the new machine tool from the laboratory to a production line where engineers could study its performance under factory conditions while it turned out television and radio set chasses. Preliminary observations indicate that the machine needs only 30 minutes for programming—an operation that includes locating all holes on an x- and y-axis and then placing that data and diameter information on the plastic memory; this compares to two days required to make a template for use in the conventional technique.

As for future applications of such equipment, GE sees its widespread use in job shop operations. And, according to Walter Hausz who directed the research for GE, the techniques that make the punch press perform automatically could be applied to other production tools, automating such processes as drilling, riveting, stapling and electrical testing.

ELECTRONIC DIGITAL COMPUTER supplies the information and hydro-pneumatic servo moves parts of the experimental automatic punch press developed by the General Electric Company as part of a Signal Corps program to make electronic subassemblies automatically.

Tax Revisions Help Research

WASHINGTON—Congress is studying legislation aimed at encouraging more research and development by private industry. The tax revisions—part of the Eisenhower program to keep business expanding—seem sure of passage in one form or another. And they'll help small business the most.

The major proposal, backed by the House Ways and Means Committee and the Administration, would permit a company to deduct, as a cost of doing business, any money spent in research and development aimed at creating new products or processes.

Under present legislation, large companies with sizeable research staffs have been able to convince the Bureau of Internal Revenue that such expenditures are an essential part of their cost of doing business. But many small companies do not receive that treatment. Instead, the small fellows have had to put research funds into a special category, treated as a capital investment, not expenses.

Such a situation inflicted a hardship on the smaller organizations. If their research resulted in a product or process that produced earnings for the company, then the expenses could be deducted from the profits. But if the research failed to produce a money-maker, then the expenditures could conceivably never be deducted at all from tax payments.

According to sympathetic congressmen, the new law should give a small company three choices: 1) deduct its research expenses each year, or 2) amortize them over a given period of years, or 3) treat them entirely as a capital investment. However, once a company makes its choice, it would have to stay with that method of treating research and development costs, unless the Internal Revenue Service grants permission to change. By switching back and forth indiscriminately, a company could skip taxes that would otherwise be due, depending on whether the tax rates were going up or down.

NEW APPROACH to reducing industrial noise is represented by the Sonosorber, a volume absorber that can be hung to isolate noisy locations. The units have inner cores encased in perforated stucco embossed aluminum; they can be used in clusters or honeycomb patterns; and they have a high value of noise absorption in both high and low frequencies.

German Patent Office Catches Up

BONN—West German inventors are filing patent applications at a record rate, but the new, enlarged patent office at Munich is keeping abreast of the application flood. Last year, the office received over 60,000 requests for invention protection, practically all originated by Germans. And it has almost cleaned up the backlog left by war activity and the period immediately after the war when no German patent office existed.

When the West German Patent Office opened its doors in October 1949, it started operations with a staff of 432 employees. It had lost most of its checking records and had few trained personnel.

Today, more than 1,500 people are working under the supervision of Prof. Dr. Eduard Reimer, processing patent applications. They're rebuilt the checking library to 300,000 volumes and set up sections to distribute film negatives and positives of patent applications as well as specifications. A Berlin branch office has been set up to process the renewal of old patents and trade marks, as well as to handle patents and trade marks conferred prior to 1945 but for which patent specifications could not be issued.

Since 1949, over 300,000 applications have been filed. In addition, there are 80,000 applications that were filed in Berlin prior to 1945 and these need processing.

Total number of applications entering the patent office is increasing:

1950	53,375
1951	55,457
1953	over 60,000

The number of applications from foreign countries reached its peak in 1950 and has since been declining:

1950	21,595
1951	9,757
1952	10,180

Figures for 1953 are not yet available, but apparently there will be a new low for foreign requests.

It's difficult to determine exactly where inventions are coming from, but office workers have noticed a definite shift in one trend: today over 80 percent of all applications come from industrial firms. Previously, retired engineers and independent workers were responsible for a greater share. And the number of applications coming from individuals is diminishing.

For 1954, the office is expecting another record year.

FADING RESISTANCE is measured in this device that duplicates the intensity of sunlight in various climatic zones. Hudson Motor Car Company uses tester to determine how well upholstery, plastics and paints will resist deterioration in sunlight.

News Briefs

• Big 19 in. tricolor television picture tubes will be available by the end of 1954, predicted RCA as the company turned over design data to its licensees. Previously, biggest color tubes available were 15 in. diagonally across the corners.

• Atomic Energy Commission staggers the imagination with their latest project: proposed construction of a 25 billion electron volt atom smasher. The new proton accelerator will be built at Brookhaven National Laboratory at a cost of $20,000,000.

• Largest magnesium casting ever poured was ordered by Western Electric from the Rolle Manufacturing Company. The record breaking part, to be used as a base for military electronic equipment, weighs 1,630 lb; its dimensions, 114 x 93 x 33 in.

• Effect of industrial noise on hearing loss is the subject of a recent 60-page report prepared by the American Standards Association. Copies of the booklet, which is directed toward the eventual development of standards and criteria for noise control, are available from ASA. Price: $1.50 per copy.

• New Director of the Engineering Experiment Station at the Georgia Institute of Technology is Dr. Paul K. Chapman, formerly director of the School of Chemistry. He succeeds Dr. Herschel H. Cudd who left to accept a position in industry.

• American Die Casting Institute will receive nominations for the 1954 Annual Doehler Award until April 15. A plaque and a five hundred dollar prize are awarded each year for the outstanding contribution to the art of die casting as represented by 1) technical achievement, 2) advancements in plant operation, or 3) other activities not primarily of a scientific or operational nature.

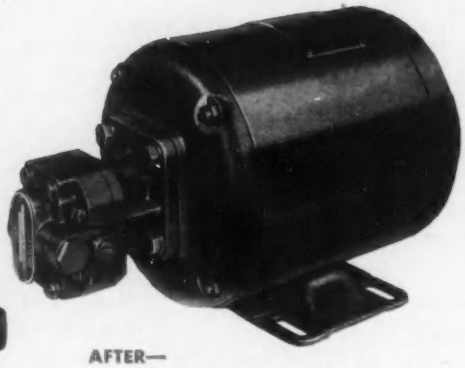
• Dean Thorndike Saville of New York University, College of Engineering, has been elected president of the Engineers' Joint Council for 1954. A prime interest: the continuing technical manpower shortage.

BARNES PUMPS TEAM UP WITH DOERR MOTORS

for better design

Constant-Flo motor pumps are smaller, weigh less, eliminate alignment problems.

BEFORE—
Conventional, separate pump and motor mounted on cast base plate.



AFTER—
Constant-Flo motor pump combination results in compact, lightweight unit.

HERE is a new "Pressure Package" made possible through a unique close-coupled construction. This line of rotary gear pumps, manufactured by the John S. Barnes Corporation, Rockford, Illinois, can deliver pressures up to 3000 psi. Motors are available in the NEMA 42, 56 and 66 frames in a range from ⅛ to 1½ hp.

The rapidly growing list of applications already includes automatic door operators, forced lubrication, filters, material stackers and elevators, crimping machines, vegetable dicers, fuel oil transfer, coolant pumps, chair lifts and machine tools.

This is another example of product improvement—the use of Doerr motors provided the manufacturer with the proper engineering features as well as a reliable source of supply. We would be pleased to consult with you on your motor applications.

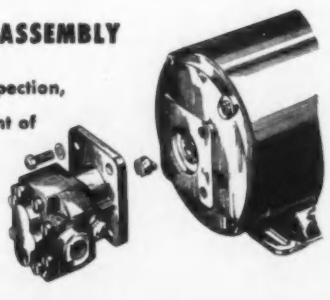
YOU GET MORE WITH DOERR!

DOERR
Electric Corporation
CEDARBURG, WISCONSIN

Electric Motors from 1/30 to 5 hp. Standard or Designed to Your Specifications

SIMPLIFIED ASSEMBLY

Permits easy inspection, quick replacement of motor or pump.



Spring Design Data

HAROLD C. R. CARLSON
The Carlson Company
New York 7, N. Y.

THESE DATA INCLUDE: Allowable working stress curves for compression springs subjected to various types of service. The "light service" category includes springs with static loads and those having small deflections with low stress ranges. The number of stress reversals is between 1,000 and 10,000.

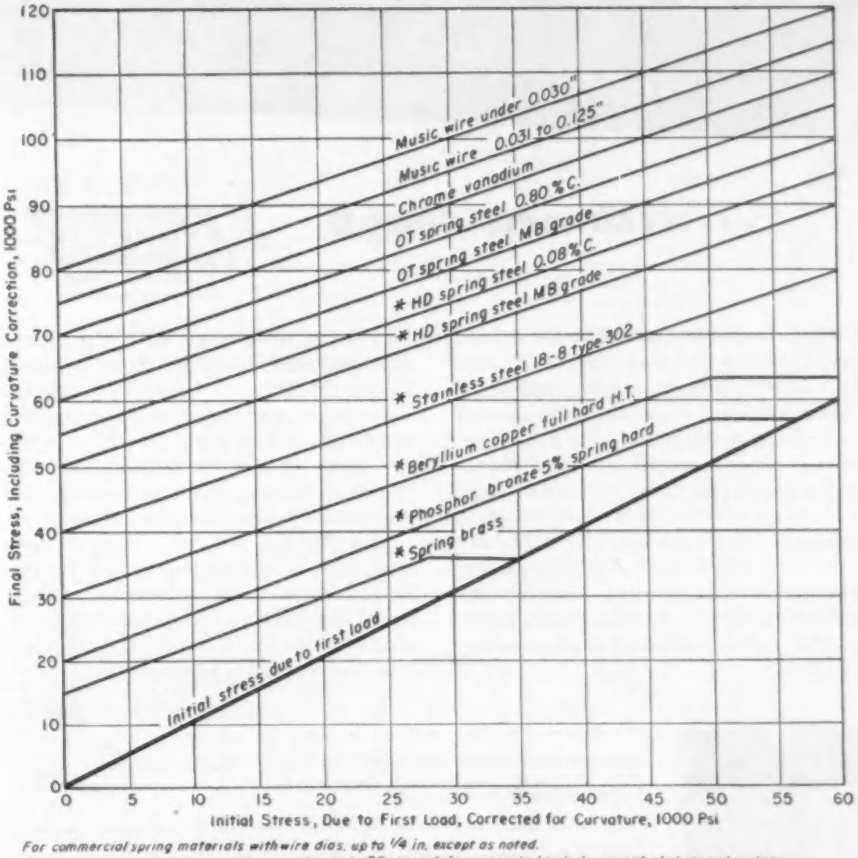
The average service group includes most springs in general use, such as those found in motors, brakes, switches, machines, and mechanical products. Normal frequency of deflection and average use without shock loading permits such springs to operate up to 100,000 reversals with infrequent breakage. More than 1,000,000 cycles have been withstood at the stress values for these curves when the material and operating conditions were exceptionally good.

Severe service refers to rapid deflections over long periods of time as in automotive and aircraft engine valves, pneumatic hammers, hydraulic controls, etc. The stress values shown by these curves provide for a minimum of 1,000,000 cycles. For 10,000,000 cycles, which is considered an infinite life, these values should be reduced by at least 10 percent. For severe service, it is also recommended that the endurance curves, below, be considered before determining the safe allowable stress.

Also included are tables of properties of spring materials such as various steels, copper base and special alloys.

(continued on page 219)

ENDURANCE LIMIT CURVES FOR COMPRESSION SPRINGS



For commercial spring materials with wire dias. up to 1/4 in. except as noted.
Stress ranges may be increased approximately 30 percent for properly heated, pre-set, shotpeened springs.
*Materials preceded be an * are not ordinarily recommended for long continued service under severe operating conditions.*

New materials spark new ideas

...with new tough HI-TEST 88 LUSTREX Styrene Plastic

Five times tougher than general purpose styrene, Lustrex Hi-Test 88 now makes possible hundreds of new, stronger, tougher applications—like this molded automobile battery case, for example, or housings for office equipment, vacuum cleaners, carpet sweepers, phonographs, electric fans, radios and dehumidifiers.

Monsanto's Hi-Test 88 has been developed without sacrificing the excellent moldability of Lustrex—which permits intricate design, molding in combination with inserts, and the "integral" molding of handles, panels, plates, or other parts—eliminating many assembly operations.

With greater hardness and better resistance to strain than other high-impact styrenes, Lustrex Hi-Test 88 also retains good light stability, and superior appearance including excellent surface finish. And where needed, as in battery cases, Hi-Test 88 furnishes the well-known outstanding chemical properties and good electrical characteristics of Lustrex.

Monsanto has prepared a study of new-application possibilities for Lustrex Hi-Test 88, showing how different types of products can be improved in performance and appearance with this new material. If you'd like a copy, just use the handy coupon.

MONSANTO

SERVING INDUSTRY . . . WHICH SERVES MANKIND

MONSANTO CHEMICAL CO., Plastics Div., Room 2103, Springfield 2, Mass.
Please send me your new booklet of design ideas in Lustrex Hi-Test 88 styrene.

Name & Title _____

Company _____

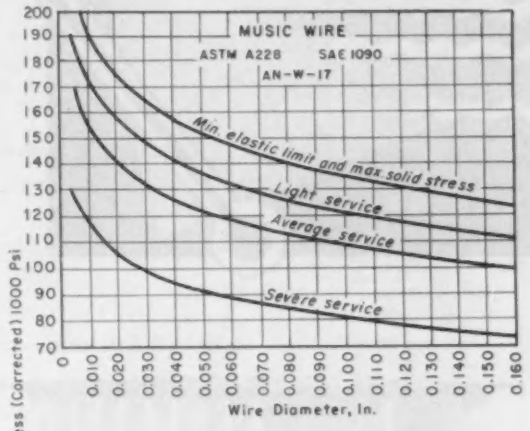
Address _____

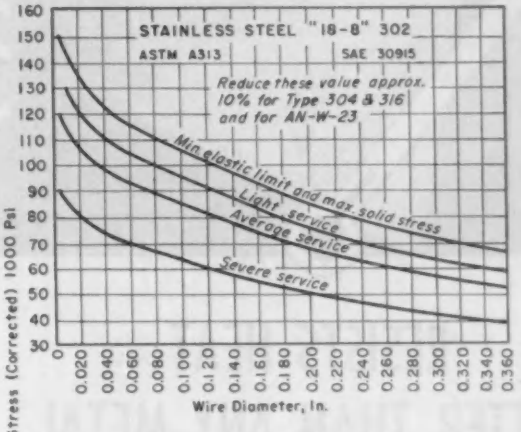
City, Zone, State _____

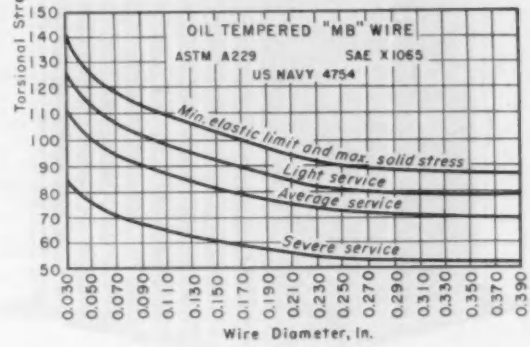
(continued from page 217)

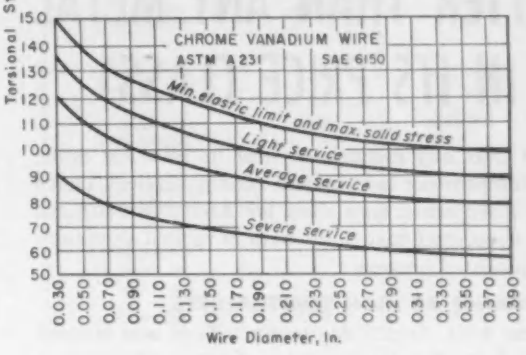
ALLOWABLE WORKING STRESSES FOR COMPRESSION SPRINGS

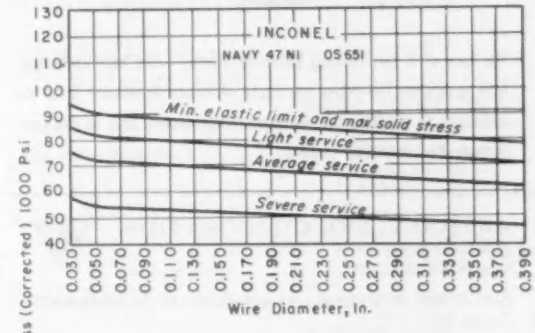
(Fatigue Strength Curves)

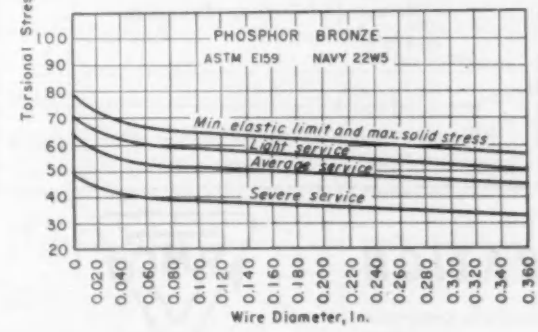


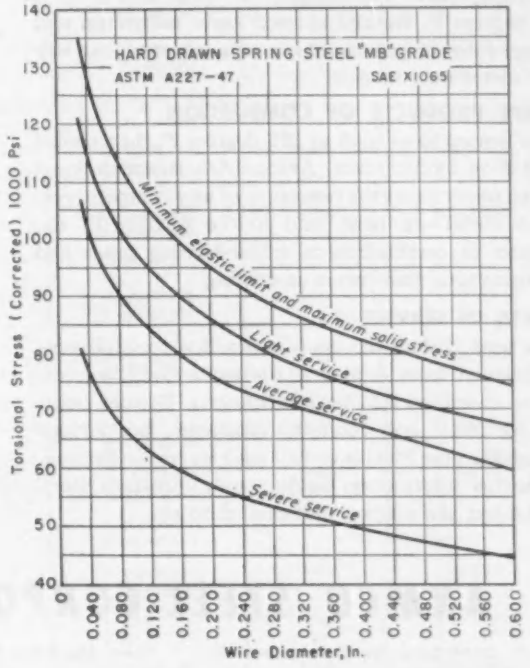

STAINLESS STEEL "18-8" 302
ASTM A313 SAE 30915
Reduce these value approx. 10% for Type 304 & 316 and for AN-W-23
Min. elastic limit and max. solid stress
Light service
Average service
Severe service
Torsional Stress (Corrected) 1000 Psi
Wire Diameter, In.











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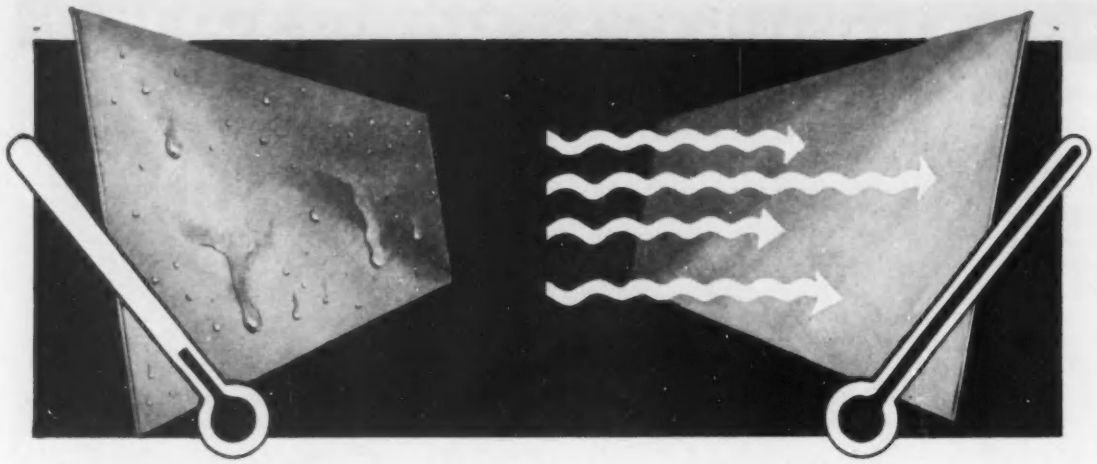


RESISTS HEAT BETTER THAN ANY METAL IN ITS PRICE CLASS!

Better than any metal in or near its price for cyclic high temperature heating and cooling service! That's what independent tests show for Armco ALUMINIZED Steel, sheet steel coated in a bath of molten aluminum by a patented process.

ENDURANCE AT HIGH TEMPERATURES

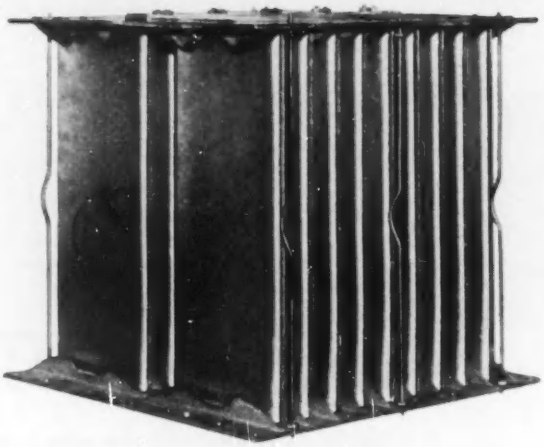
In these tests, Armco ALUMINIZED Steel was exposed to burning sulfur-bearing gases at temperatures up to 1325 degrees F. Results showed lower maximum and average rates of penetration in mils per year than any other metal near its cost.

RESISTS PRODUCTS OF COMBUSTION

When heated to as high as 825 degrees F, then cooled to 80 F in cyclic tests, Armco ALUMINIZED Steel showed many times the resistance of any competitively priced metal—to heat, and to the mixture of the products of combustion of sulfur-bearing gases and the condensate that forms on cooling.

PROVED IN SERVICE

These tests explain the many years of successful service obtained from Armco ALUMINIZED Steel in combustion chambers and heat exchangers. Besides being used for heat- and corrosion-resistance, this Armco Special-Purpose Steel is widely used for heat reflection. For further information on Armco ALUMINIZED Steel, just fill out the coupon and mail it to us.



The core of a gas-burning industrial heater—the heat-exchanger tube assembly. The tubes are made of Armco ALUMINIZED Steel for resistance to oxidation at elevated temperatures, and to the condensate that forms on cooling.

ARMCO STEEL CORPORATION
2244 Curtis Street
Middletown, Ohio

Send me information on Armco ALUMINIZED Steel for

☐ Heat- and Corrosion-Resistance
☐ Heat Reflectivity

NAME_____

FIRM_____

STREET_____

CITY_____ ZONE____ STATE_____

ARMCO STEEL CORPORATION

2244 Curtis Street, Middletown, Ohio • Export: The Armco International Corporation

(continued from page 219)

PROPERTIES OF SPRING STEELS

Material (Commercial Name)	Specifications In General Use	Modulus of Elasticity	Density lb/cu. in.	Recommended Rockwell Hardness
Hard Drawn MB Spring Steel	ASTM A227-47 SAE X1055 & X1060 Army 48-6A	G 11,400,000 E 28,500,000	0.284	C41-C45
Music Wire Spring Steel	ASTM A228-41 SAE 1085 Navy 22W11 Army 48-18 AN-W-17	G 12,000,000 E 30,000,000	0.284	C42-C46
Oil Tempered MB Spring Steel	ASTM 229-41 SAE X1065 Navy 47S4 Army 48TA Fed QQ-W-474	G 11,200,000 E 28,500,000	0.284	C42-C46
Chrome Vanadium Alloy Steel	ASTM A231-41 SAE 6150 Navy 46S31 Army 48-7A AMS 6455A	G 11,200,000 E 30,000,000	0.284	C45-C49
Silico-Manganese Alloy Steel	ASTM A59-49 SAE 9260 Navy 46S31	G 10,750,000 E 29,000,000	0.284	C43-C47
Silicon-Chromium Alloy Steel	Special	G 11,200,000 E 30,000,000	0.284	C50-C54
Stainless Steel Type 302 (18-8)	ASTM A313-47 SAE 30915 Navy 46S18	G 10,000,000 E 26,500,000	0.288	C42-C47
Stainless Steel Type 304 (18-8)	SAE 30905 Army 48-37 Navy 46S18	G 10,000,000 E 26,500,000	0.288	C42-C47
Stainless Steel Type 316 (18-12 MO)	SAE 30805 Navy 47S21 & 22W13 AN-W-23	G 10,000,000 E 26,500,000	0.288	C42-C47
Stainless Steel Type 17-7 PH	Special	G 11,000,000 E 29,500,000	0.276	C40-C45
Stainless Steel Type 414	SAE 51210	G 10,500,000 E 28,500,000	0.288	C43-C48
Stainless Steel Type 420	SAE 51335	G 11,000,000 E 29,000,000	0.280	C46-C51

PROPERTIES OF COPPER BASE AND SPECIAL ALLOYS

Spring Brass Type 70-30	ASTM B134-46 (6) Fed QQ-W-321 (C) SAE 80	G 5,000,000 E 15,000,000	0.308	B89-B93
Phosphor-Bronze, 5 percent tin	ASTM B159-46 (A) SAE 81 Navy 22W5 Fed QQ-W-401	G 6,000,000 E 15,000,000	0.320	B95-B105
Beryllium-Copper Type 2¼ percent	ASTM B197-51T AMS 4725A MIL-C-6941A	G 7,250,000 E 19,000,000	0.315	C37-C40
Inconel & Inconel X	Navy 47N12 & OS-651 Navy-W-41 Fed QQ-W-390	G 10,500,000 E 28,500,000	0.309	C38-C42
Monel	Navy 46M7 Fed QQ-N-281	G 9,500,000 E 26,000,000	0.319	C25-C30
K-Monel	Navy 46N5a Fed QQ-N-286	G 9,500,000 E 26,000,000	0.306	C30-C36
Z-Nickel	Special	G 11,000,000 E 30,000,000	0.316	C41-C45
NI SPAN C	Special	G 10,000,000 E 26,500,000	0.294	C40-C44
Elgiloy	Special	G 12,000,000 E 29,500,000	0.300	C54-C58
Iso-Elastic	Special	G 9,200,000 E 26,000,000	0.294	C30-C36

NEW COMPONENTS-

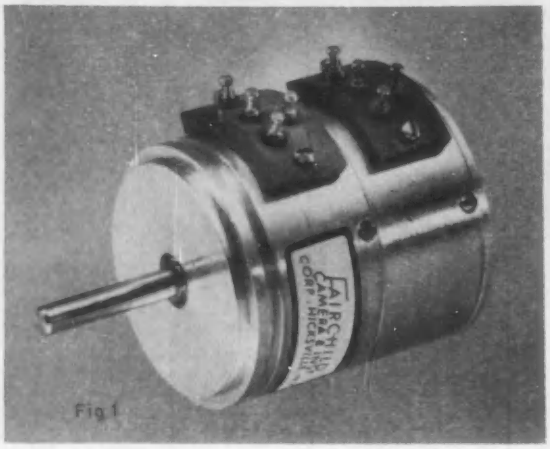


Fig. 1

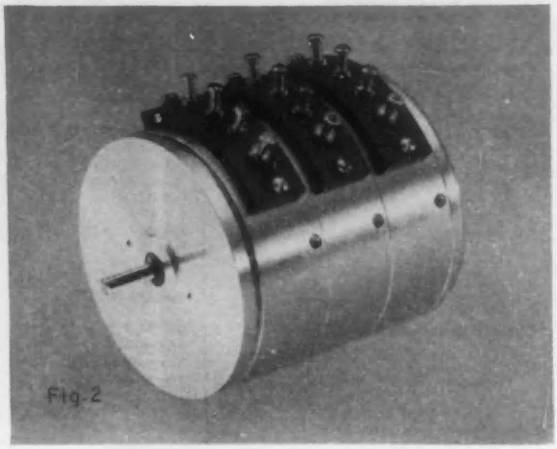


Fig. 2

New Line of Potentiometers Features

Shown here are five of a new line of potentiometers having application in computers, automatic programming devices, fire control, simulators, servomechanisms for machine tool and process controls, and the like.

Internal clamp rings make the new type 741 potentiometer gangable without increasing the overall diameter of the unit. This new unit, Fig. 1, is only $1\frac{1}{8}$ in. in diameter by $1\frac{1}{4}$ in. long, and utilizes a one piece front cup with internal clamp arrangement enabling up to a 5 ganged unit to be assembled.

Provision for two single wire welded taps is a standard feature. A one piece Paliney wiper and simplified slip ring construction give good life characteristics with low noise and high resolution.

Available in medium resistance ranges, the type 741 has a linearity of ± 0.5 percent or better, and has a standard electrical rotation angle of 350 degrees. Mechanical rotation is continuous. Available with standard synchro mount, the 741 potentiometer has a newly designed radial type terminal board, and can be furnished with or without ball bearings. The unit has gold plated terminals and a $\frac{1}{4}$ in. diameter shaft.

Applications for which the new model has been designed include fire control, telemetering, computers, and automatic programming devices.

Shown in Fig. 2 is the second in a series of linear potentiometers featuring the new internal clamping arrangement. Internal clamp bands permit ganging of up to 8 units on a single shaft giving a smooth exterior surface. Phasing of the various cup sections is simple and accurate. Type 754 is the second of a series of linear function units. Similar in design to the type 741 shown in Fig. 1, the type 754 offers high linearity in a wide resistance range.

Linearity is rated at ± 0.15 percent standard, ± 0.10 percent special. Resistance range is 800 ohms to 100,000 ohms standard. High resolution, 0.030 percent maximum, a nominal effective electrical angle of 356 deg. ± 0.5 deg, and a power rating of 5 watts in a single cup section, are other features. The type 754 potentiometer is normally supplied with a servo-flange mounting.

The model 754 is 1.990 in. in diameter. Length of a single cup is 1 in. including the servo-flange. Additional cup sections add 0.594 in. per section to the length. All cups are machine aluminum. Shaft diameter is $\frac{1}{4}$ inch.

Typical application for the type 754 is in military equipment such as guided missile control, computing gunsights, bombsights and training equipment, simulators, navigational and fire control equipment and aircraft engine controls. Commercial uses would include servo-mechanisms for machine tool and process controls, sensing and transducer equipment, instrument controls and attenuators in industrial equipment, including electrical and electronic test equipment, and in high speed computers.

The model 745, 10-turn helical type potentiometer, Fig. 3, has a resistance range of 100 to 300,000 ohms, ± 0.5 percent, a linearity tolerance of ± 0.025 percent 5000 ohms and over, and ± 0.05 percent under 5000 ohms. It meets electrolysis and humidity, high altitude, vibration, load life, and temperature cycling tests under JAN-R-19; shock, sand and dust, salt spray, and high temperature under requirements of MIL-E-5400, and fungus resistance tests under MIL-E-5272A.

Electrical noise level is low and does not vary with life. Terminals are gold plated for reduced contact resistance, low corrosion factor, and faster soldering, and are mounted on the terminal board located on the potentiometer body behind the mounting flange.

The model 745 is 2 in. in diameter at the servo flange; length from the front of the flange to the end of the case is $2\frac{5}{32}$ in. maximum. It dissipates 5 watts at 40 C, and has

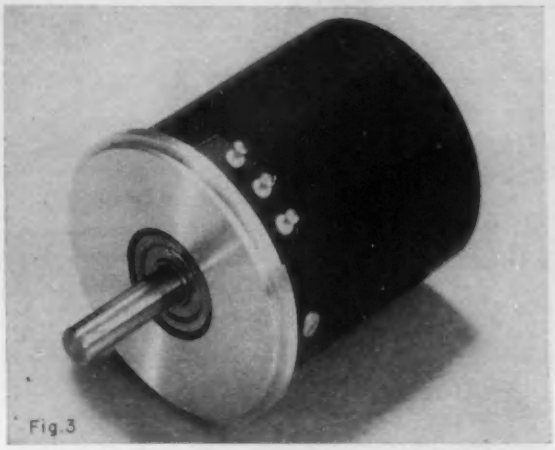


Fig.3

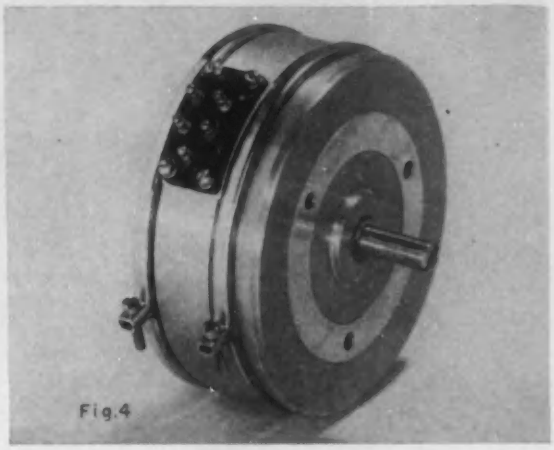


Fig.4

Small Size and Precision Applications

a starting torque of 1 oz.-in. at ambient temperature. Mechanical and electrical rotation is 3600 deg +2 deg, —0 degree. The unit weighs 7 ounces.

The 3 in. continuous since-cosine potentiometer, type 753, Fig. 4, utilizes two wipers spaced 90 deg apart to furnish full function sine-cosine outputs. This type is also available as a straight sine function with a single wiper. It is 1¼ in. long from the front of the servo flange to the rear of the cup.

Easily ganged up to 6 cups, this precision device will easily provide for full sine-cosine function in computer applications without resorting to mechanical cams and linkage arrangements.

Standard resistance value is 20,000 ohms per quadrant. Standard linearity tolerance of ±0.5 percent of the peak-to-peak output is offered.

Torque of shaft per cup section is 1.5 oz.-in. for single wiper, and 2.0 oz.-in. for dual wiper at 25 C. All terminals are gold plated for reduced contact resistance, low corrosion factor, and faster soldering.

The new metallic film type potentiometer, model 771, Fig. 5, claimed by the manufacturers to be the first metallic film type potentiometer on the commercial market, is for semi precision applications where the characteristics of infinite resolution, high temperature operation, high wattage dissipation, and very wide resistance range in a small size unit are called for.

A few such applications for this unit are: servo feedback control systems, electronic computers, guided missiles, jet engine controls, radar, electronic panel controls, trimmers, motor driven devices, and transducer elements such as in telemetering systems.

This potentiometer, called the FilmPot, has a resistance element of precious metal deposited on an inorganic substance which is electrically stable up to temperatures of 225 C. This resistance element assures a low temperature coefficient of resistance over a range of 100 to 200,000 ohms in the ¾ in. case size. Low noise, good service life, and low torque are other features.

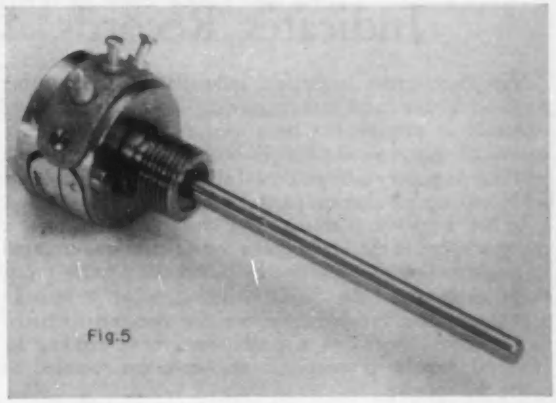


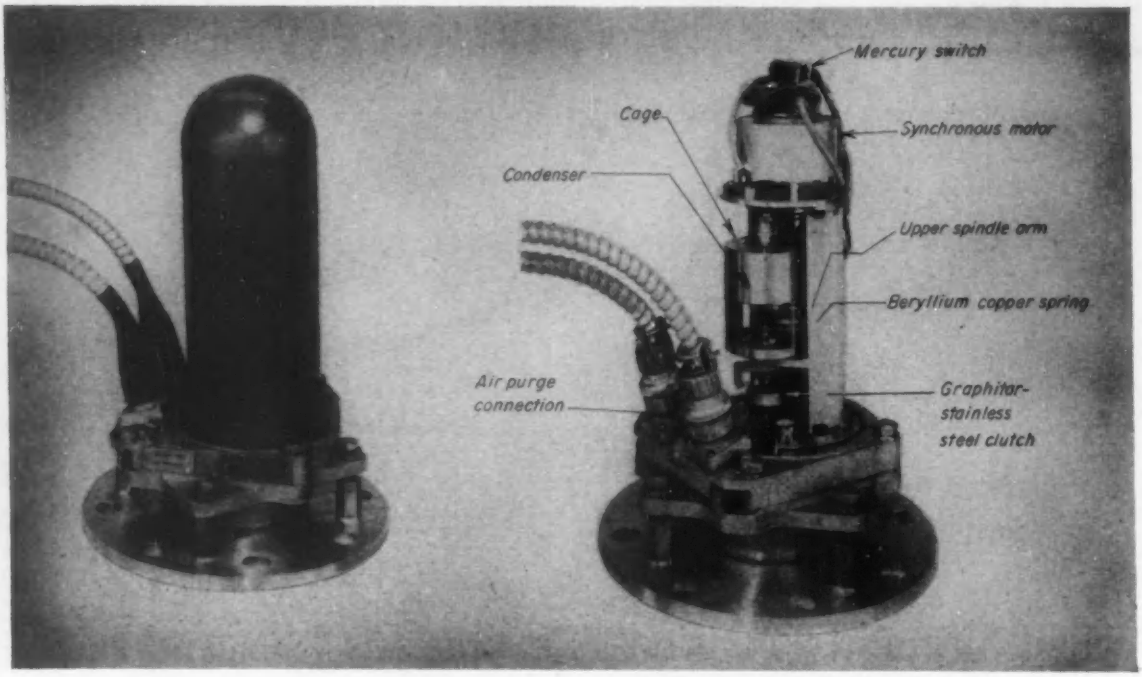
Fig.5

The infinite resolution of a metallic film resistance element in servo applications limits hunting and oscillating of the mechanisms, a common fault of step wire wound potentiometers.

The model 771 is ¾ in. in dia and ½ in. long. It is available with either servo-flange or threaded brushing mountings, and meets JAN-R-19 specifications for salt spray, vibration, temperature cycling and low temperature requirements.

Fairchild Camera & Instrument Corp., Potentiometer Div., 225 Park Ave., Hicksville, N. Y.

CONTINUED ON PAGE 224



Indicates, Records, And Controls Viscosity

The viscometran, a flexible industrial instrument that gives an accurate and continuous viscosity measurement of materials in process, has been used successfully under a variety of corrosion and temperature conditions with such products as paper coatings, crystal slurries, polyvinyl acetate solutions, catalyst slurries, paint solutions, and glues.

In use, a spindle is rotated by a synchronous motor at a constant speed in the liquid under test. The torque required to produce this rotation is directly proportional to the centipoise viscosity of the fluid. Utilizing either a variable capacitance or a variable resistance, the viscometran transmits a viscosity signal to a suitable receiver by sending an electrical impulse proportional to the torque required to rotate the spindle.

Viscosity is measured at a constant rate of shear since the spindle of the viscometran rotates at a constant speed. Fluids such as slurries, emulsions or paints have a viscosity which will vary unpredictably with the rate of shear at which they are measured. Measurements at too high or too low a shearing rate will not show clearly the difference between many such materials. Measurements at a varying rate of shear fail to relate viscosity to any reference point and merely indicates an averaging effect.

The instrument may be used for applications involving base mount temperatures up to 200 F, and in a vacuum from 8 mm of mercury to pressures of 100 psi. All moving parts are mounted on aluminum castings and are enclosed by a $\frac{3}{32}$ in. steel valve cap. The base of the viscometran is also cast for maximum strength. Shown in the illustration is the instrument with the cover in position (left) and removed (right). Mounting is on a 4 in. 125 lb. flange.

Brookfield Engineering Labs., Inc.,
240 Cushing St., Stoughton, Mass.

THE SERIES 80 MIDGET TELEPHONE TYPE RELAY, a compact, multiple contact relay with vibration and shock-proof characteristics, has coil windings rated for d-c voltages up to 115 v, and palladium contacts rated at 3 amp non-inductive load at 24 v d-c or 115 v, 60 cycles. On special order, they can be supplied with silver contacts which are rated at 5 amperes. The new sensitive relay is available in open form for surface mounting or in hermetically sealed containers. The smallest, in the sealed types, measures $1\frac{5}{8}$ inches x $1\frac{3}{32}$ inches x $1\frac{21}{32}$ inches. Signal Engineering & Manufacturing Co., Long Branch, New Jersey.

INTERCHANGEABLE WITH immersion-type centrifugal pumps, and designed for pumping coolants contaminated with abrasives, a new immersion pump has been developed for use in the machine tool field. The new pump is capable of pumping coolants in the varying viscosities of all commercial coolants, and has been adopted for use on lathes, grinders, millers, automatic screw machines, planners, and others. Pedestal dia is $2\frac{3}{8}$ in., and heights are 10 and 12 inches. Made to J.I.C. standards. Associated Engineers, Inc., P. O. Box 1628, Springfield, Mass.

CONTINUED ON PAGE 226

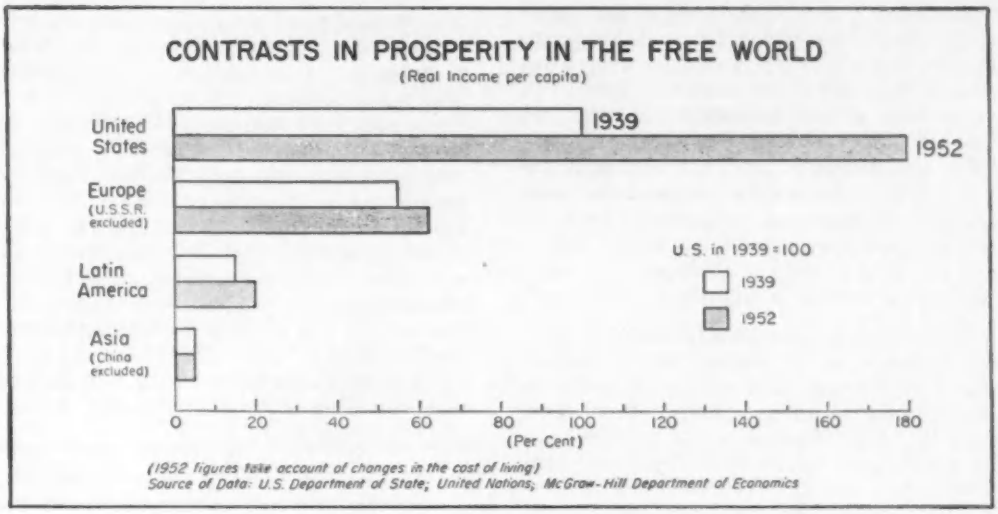
Contrasts in Prosperity Endanger the Free World

The chart in the middle of this page summarizes a situation of profound importance to every American. It shows that:

1. On the average, Americans are vastly better off economically than most other people in the free world, and
2. In recent years the gap in income between the average American and the average European, Latin American or Asian has greatly widened.

A Mounting Contrast

Even greater is the contrast between the real incomes of Asians and Americans. Today most Asians are no better off economically than they were back in 1939. On the other hand, the real income of the average American has almost doubled. As a result, the real income of the average Asian—always small by our standards—is now only a tiny fraction of that of Americans.



The chart shows that, at the outbreak of World War II, the real income (that is, actual purchasing power of income) of the average American was substantially higher than the average European's and much higher than the average Latin American's or Asian's. Since then, the European and Latin American have become better off. But the improvement in the economic lot of the average American has been so great that the others have been left far, far behind.

It must be remembered that the figures used to construct the chart are of varying quality. The fact is that few of the poorer countries have reliable statistics. However, it is generally agreed among competent observers, that the figures here presented offer a correct impression of the wide disparity in the average of real incomes between various parts of the free world. The figures, of course, have nothing decisive to say about spiritual and cultural values. In these, coun-

tries with relatively little material prosperity may be rich.

It is possible to draw a variety of morals from the story of lagging growth of income in other parts of the world. For one thing, it reflects the dynamic force of private enterprise. Private enterprise is characteristic of our economy far more than it is of most of the other free economies. The chart also reflects the fact that we are bountifully blessed with the natural resources essential to a high level of real income. Moreover, we did not suffer from the devastation and waste of two world wars as did many of the other free nations.

Narrowing the Gap

But perhaps the most important message which the chart conveys is one of warning. It warns that something must be done to narrow the gap in prosperity between America and other parts of the free world, if that world is to be united successfully in the struggle against totalitarian Communism. Writing in the HARVARD BUSINESS REVIEW, Kenneth E. Boulding recently put it this way:

> *"The crux of the problem is how to raise the three-quarters of the world that live on a low level to the high level of the other quarter, for it is precisely this wide disparity that makes our world so unstable. American-Russian relations, for instance* [*are*] *... complicated almost unbearably by the fact that each power is competing for the support of the vast fringe of underdeveloped countries... These countries are dissatisfied with their present state and are hovering between the two cultures, wondering which offers them the best chance of shifting from their present low-level to a high-level economy."*

Very real danger threatens from any feeling which may develop in the less fortunate free nations that our enviable economic progress has been made at their expense. Instead of viewing the American economic system as a model that might be followed by their own countries, they may be led to see in it a menace to their well-being. If Communist propaganda can persuade these people that their alliance with the free world will only result in their dropping farther and farther behind an increasingly prosperous United States, they will be driven to the side of totalitarianism.

Test of Effective Leadership

How can these free nations on the lower half of the income ladder be helped to alleviate the conditions that keep them there? Surely this question poses a whole series of complicated problems. Yet, if we do not exercise some effective leadership toward their solution, we can be sure that Russia will take advantage of the situation. In these circumstances, it is essential to both the stability and security of the free world that we help our less prosperous neighbors make satisfactory headway.

This does *not* mean that the United States should sacrifice its own economic progress in favor of some sort of global leveling scheme. On the contrary, a continually expanding and stronger economy is essential if we are to provide any real aid to our friends. Also, it goes without saying that our friends must be disposed to do all they can to improve their own economic position, if our cooperation to that end is to be effective.

Great Skill Required

Our part in a program to achieve this goal calls for a high degree of skill and statecraft. It involves international trade policy, which, in itself, presents a perplexing range of problems. It involves also programs of foreign technical and economic assistance. And expanded foreign investment must play a key role in a balanced program to strengthen the economies of the free world for our common good.

The Commission on Foreign Economic Policy, headed by Clarence Randall, has recently submitted a report, embodying the results of a monumental inquiry into our foreign economic relations and measures to improve them. From the very nature of the subject, discussion of the report is bound to be attended by much controversy and conflict. However, an awareness of the facts presented by this chart should inspire us to accord to the problems posed by the Randall Commission the careful and sober consideration they must have if any real progress is to be made in raising the general standards of human well-being throughout the free world. Our willingness and ability to do this have now become the real test of our statesmanship, both at home and abroad.

This message is one of a series prepared by the McGraw-Hill Department of Economics to help increase public knowledge and understanding of important nationwide developments that are of particular concern to the business and professional community served by our industrial and technical publications.

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Donald C. McGraw

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The POWER that Builds Reputations

KNOWLEDGE

SKILL

SERVICE

RESPONSIBILITY

R.D. THE PEERLESS ELECTRIC COMPANY 1893

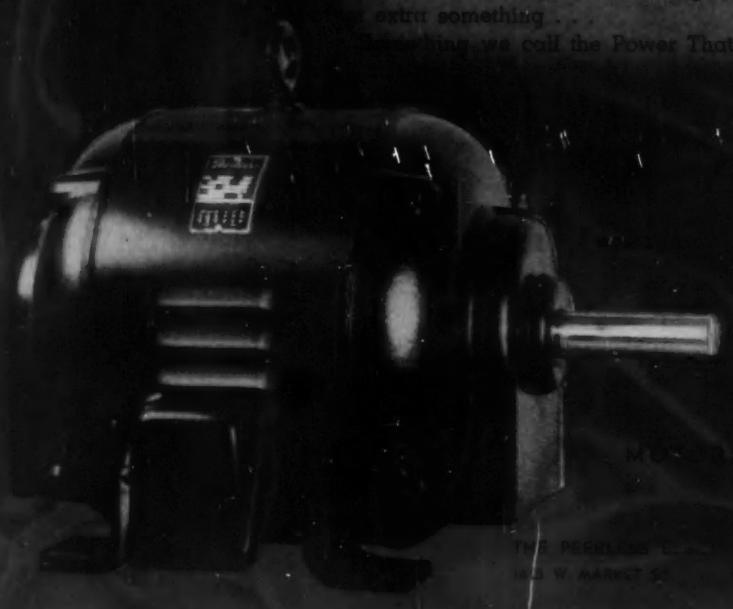
Peerless

PREMIUM-BUILT ELECTRIC MOTORS

No greater compliment can be paid a motor than to call it Peerless. The men who build, sell and service America's finest mechanical equipment know what we mean.

"Service" by our representatives; "knowledge" of Peerless engineers; "skills" of its manufacturing personnel; and, "responsibility" of Peerless top management result in a motor with that extra something. Yes, The Peerless Electric Company is proud to build motors with that extra something . . .

Something we call the Power That Builds Reputations.



Peerless Electric

Metallic Bellows Have Greater Expansion

Welded-diaphragm type metallic bellows, originally developed for atomic energy application, are now available in a variety of standard sizes and in any one of several different metals. Features are long life under severe conditions of corrosion, vibration and high temperature, permitting use as a shaft seal, expansion joint, and vibration absorber in the aviation, ordnance and chemical fields.

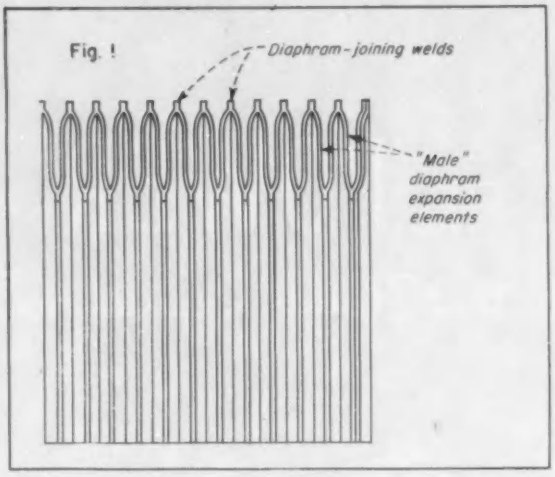
The welded diaphragm construction distributes flexing over the entire height of the convolution, thus avoiding the concentration of flexing at the bend and the resultant work hardening that leads to bellows failure.

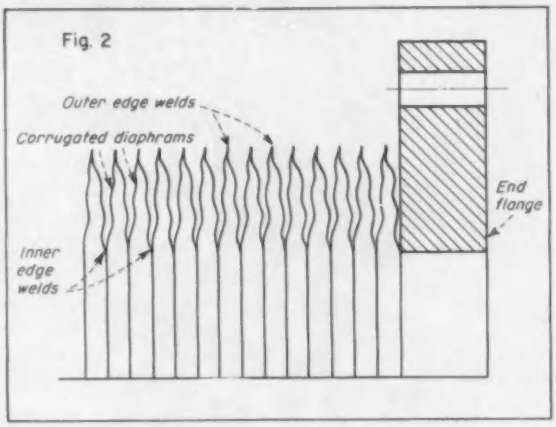
The manufacturers claim that this construction also affords the following advantages over the bellows of conventional construction: (1) Flexibility can be increased by increasing the height of bellows convolutions. This permits producing a bellows having the great flexibility required for lines conveying gases or liquids at low pressure. At the same time, this flexibility can be attained with metal of sufficient thickness so that these bellows for low pressure lines can withstand the high external pressures such lines are often subjected to; (2) The increase of flexibility with height of convolution also permits greater expansion range for every inch of bellows length than is possible with conventional bellows construction.

Two types of bellows using this new construction are in production. The standard type, consisting of a series of male expansion elements (Fig. 1) and the nesting type, comprising a series of nesting male-and-female expansion elements (Fig. 2) for extreme flexibility applications. The manufacturers claim that compared to conventional bellows, the new nesting type has an expanded length 5 times greater, and a compressed length 1.65 times greater.

The nesting type, results in a flexible bellows especially suited for low pressure air and steam lines. The nesting construction permits extreme lineal movement.

The male-expansion-element type bellows is produced in a range of 50 standard sizes from 1.0 inch ID up to 36.0 inch ID, depending on the application. The nesting type can be produced in a range of 27 sizes, from 0.687 inch to 7.375 inch ID. In this type a standardized 1-inch convolution height for all sizes has been established but smaller or larger ones can be provided for special use.





Titeflex, Inc., 500 Frelinghuysen Ave., Newark 5, N. J.

General Purpose Aluminum Offers Weight Savings

Structural cost and weight savings are expected as a result of the development of 66 S, a new general purpose aluminum alloy, said to bridge the gap between the lower strength of 61 S type alloy and the higher strength hard alloys, 24 S and 14 S.

The savings in weight by 66 S permits its use in structural elements, resulting in a cost saving over thicker sections of alloys.

Characteristics of the alloy are similar to that of 24 S in yield strength, and the fabricating characteristics are almost identical with that of lower strength 61 S. The new 66 S alloy has a yield strength of 45,000 psi, and has guaranteed tensile and yield strengths 31 percent over 61 S alloy. Also, 66 S has a tensile strength of 50,000 psi for material up to ¼ in. thick, 45,000 psi yield strength, and 8 percent elongation. Higher strengths are guaranteed in ¼ in. material and over. The manufacturers claim that 66 S alloy has many advantages over other structural metals, such as structural steel, for example, which has a yield strength of 33,000 psi.

Corrosion resistance of 66 S is similar to 61 S, and is said to have a greater resistance than 24 S and 14 S aluminum. Some of the applications will include: the building, truck and trailer, and aircraft industry; heavy construction, and general parts fabrication.

Harvey Aluminum Company, Torrance, Calif.

CONTINUED ON PAGE 228

WICHITA 24" *Air-Tube* Clutches Disengage in

1/27 of a second

SMALLER CLUTCHES EVEN FASTER!

For complete safety of the operator, split second disengagement is absolutely *essential!* The amazing disengagement speed of Wichita Air-Tube Clutches is due to minimum volume of air in tube and to Wichita Quick Release Valves.

Wichita Clutches are operated successfully, on many types of equipment, all over the world and *NOT ONE HAS BEEN REMOVED*. This alone proves the superior performance of Wichita Clutches. Test a Wichita . . . you'll see for yourself!

Other Major Features

- Soft, Smooth Engagement
- Simple Design
- 3 types of clutches: Standard, Low Inertia, Special Ventilated
- Efficiency Engineered
- Positively Ventilated for Cooler Operation
- Extremely Long Life
- Easier Maintenance

Consult your nearest Wichita Engineer for complete and detailed information.

WICHITA DISTRIBUTORS

Brehm-Lahner, Inc., Detroit, Michigan
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Frank W. Yerline Co., Chicago, Ill.
Power Rig & Equipment Co., Inc., Long Beach, Calif.
Robert R. King Co., Cleveland, Ohio

Ad 4DN

Pre-Coated Metal Coil Used in Forming Operations

Shown in the illustration are a few of the products made from a precoated metal strip available in a variety of widths and thicknesses, types of finishes and colors. Features are said to be: faster production time by use of automatic coil feed; lower inventory of metal stock; lower scrap loss, and elimination of the additional painting process usually required.

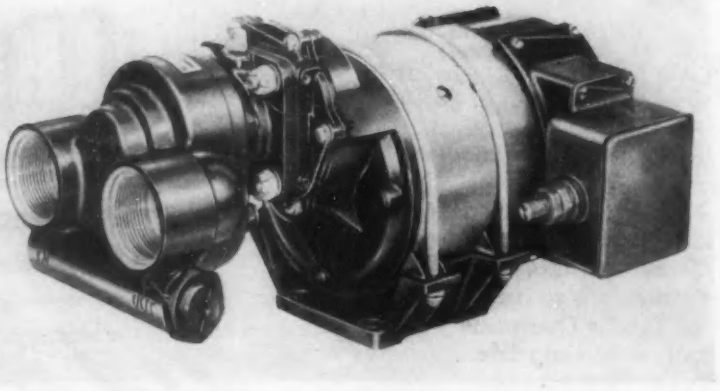
The finish is bonded to the metal by a phosphatizing process to permit stamping, piercing, intricate embossing, and drawing without damage to the finish.

Enamelstrip comes in cold-rolled steel, electro-galvanized steel, electrolytic tin plate, brass, zinc, and aluminum, in widths from $\frac{7}{32}$ inches up to 30 inches, and in thicknesses ranging from 0.006 to 0.040 inch. Fabricators have a choice of a wide variety of finishes—alkyds, ureas, alkydureas, vinyls, oleo-resinous, formaldehydes, sanitary lacquers, epons, plastics and semi-plastics, and adhesives. Film thicknesses range from 0.00005 to 0.002 inch. Heavier thicknesses may be specified.

In the various shaping processes required of the parts shown such as drawing, automatic assembly, blanking, corrugations, rolling, and joining with a lock seam, the paint was not removed from the metal base. The flashlight tubes were fabricated from red, green, blue, or black steel coil $5\frac{1}{32}$ in. wide, 0.010 gage, coated on both sides.

Enamelstrip Corp., Allentown, Pa.

Aircraft 7 Gpm Oil Transfer Pump



A new constant flow aircraft rotary gear pump, Model RG-10180, is designed for a working pressure of 300 psi at 7 gpm flow with oil at 60 F through the outlet port. A relief valve starts to open when the pressure exceeds 300 psi, so that at 500 psi all flow by-passes internally within the pump with no further increase in pressure, and no oil is discharged from pump.

Under this condition, the unit is capable of operation for one minute on and 59 minutes off.

The motor is of the geared type, 3 horsepower, 27 volts, direct current, 125 amperes, with rated duty cycle of 8 minutes on and 52 minutes off for normal oil transfer duty. The two-gear positive displacement pump operates at 2,500 rpm, and has 0.760 cubic inch displacement per revolution. In addition, it has a radio noise filter.

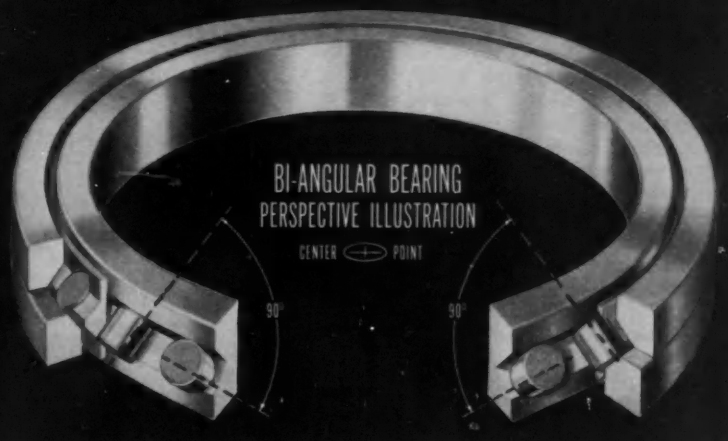
The ports are tapped 1-$\frac{5}{8}$-12N-3 thread for $1\frac{1}{4}$ inch OD tube connection. The entire pump-motor unit designed for extreme low temperature operation. There is a positive oil seal between the pump and the motor. Relief valve is adjustable. Weight is 25.9 pounds. One application of this pumps is on a four-engine airplane where it is used to transfer oil from a fuselage oil tank to each engine nacelle tank. Rotation is clock-wise when viewed from the pump end.

Lear, Inc.,
Lear-Romec Div., Elyria, Ohio

CONTINUED ON PAGE 230

Contact KAYDON of Muskegon

FOR ALL TYPES OF BALL AND ROLLER BEARINGS: 4" BORE TO 120" OUTSIDE DIAMETER



Here's a bearing that can be "custom-engineered" to your exact requirements

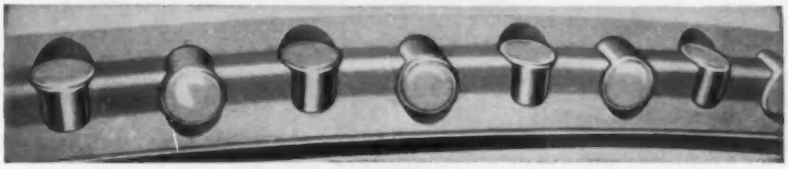
KAYDON BI-ANGULAR Roller Bearings are adaptable to various proportions of thrust and radial loads

IF you've design problems involving various combinations of thrust and radial loads, you don't have to buy separate radial bearings and separate thrust bearings.

KAYDON BI-ANGULAR Roller Bearings normally are built with every other roller reversed, and in such cases, adjacent rollers are at 90° to each other to carry both thrust and radial loads.

To handle thrust loads greater from one direction than the other, the bearing can be made with every second, third or fourth roller reversed, depending on the load inequality.

Whatever *your* bearing needs, KAYDON has all the facilities your engineers require. Whether it's only a few or many special bearings — 4" to 120" outside diameter — or millions of high-precision rollers — contact KAYDON for confidential counsel and cooperation.



Close-up shows alternate rollers reversed. KAYDON BI-ANGULAR Roller Bearings are particularly suitable for low-speed applications involving heavy impact loads.

31.000" x 34.988" x 2.000" KAYDON BI-ANGULAR Roller Bearings have been produced in large quantities and are successfully in use. They are further proof of KAYDON ability to design and make unusually large precision bearings for specific needs.

KAYDON Types of Standard and Special Bearings:
Spherical Roller • Taper Roller • Ball Radial • Ball Thrust
• Roller Radial • Roller Thrust • Bi-Angular Bearings

THE KAYDON ENGINEERING CORP.

MUSKEGON • MICHIGAN

PRECISION BALL AND ROLLER BEARINGS

Coordinating Electric with Mechanical System

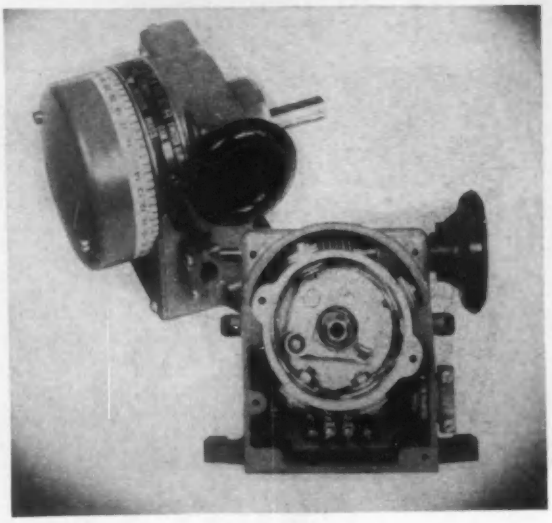
Simple, accurate means for coordinating the angular position of a rotating shaft and the opening or closing of an electric circuit are provided by an instrument called the Rototimer. This new device comprises a cam-operated single-pole single-throw switch that can be externally adjusted through 360 deg in either direction from any starting position so that the switch operates at any point in the rotation of the shaft to which the drive shaft is connected.

Adjustment is made by a handwheel that operates a 25-to-1 worm gear. A scale showing the position of the operating point, in degrees from a fixed reference point, makes repeat setting easy and accurate. The operating point of the switch can be adjusted while the connected machine is in motion, and once set, is automatically held by the high pitch of the worm gear.

The switching element is a set of automotive distributor points, noted for long life at high speed. These contacts are actuated by a hardened and polished steel cam, once for each revolution of the drive shaft. Cams are available for either normally open or normally closed circuits. The duration of open or closed circuit time can be adjusted by turning a screw; a locking screw fixes this setting.

The electrical system is designed to handle one amp at 125 v a-c. Current is fed to the contacts by brushes and slip rings allowing continuous adjustment in either direction.

Other features are: high-quality ball bearings with sealed-in lubrication; means for lubricating the actuator



cam; half-inch diameter keyed drive shaft; and cast aluminum housing. Overall dimensions of the instrument are: $6\frac{3}{32}$ in. long, $5\frac{1}{2}$ in. wide, and $5\frac{1}{16}$ in. high.

Farmer Electric Co., 21 Mossfield Rd., Waban, Mass.

Counter Will Start, Stop, Divert, or Modify Process

Production processes that involve continuous unit flow, or any movement that can be measured by an electrical device or mechanical pickup, may be monitored by a new type preset counter at speeds up to 5,000 counts per second.

The all-electronic model 164 preset counter shown is designed for industrial applications in controlling automatic machinery and processes over a wide range of rates or operating speeds, including those that exceed the reliable counting capabilities of mechanical registers.

At the instant that a predetermined value of count is reached, the instrument provides an electric circuit closure. This may be applied to start, stop, divert, modify or measure a continuous process flow, operate an alarm, record a batch, bring in an auxiliary process function or otherwise provide conclusive action as a result of the complete count.

Recycling, at the instant the predetermined count is reached, may be automatic or by independent control. An electro-mechanical register permits recording of one million of these predetermined counting cycles; as in the food processing industry, the counter would record one million cases, each containing 24, 48 or more pieces, according to the packing method.

This instrument may be used to count revolutions, strokes, electrical signals or similar impulses which recur regularly or irregularly at rates between zero and 5,000 counts per second. As a counter it will record to 10 billion units.

The counter can be set to respond to input impulses of

either polarity and any voltage between 4 and 60 volts derived from a trip wire, pressure or cam switch, relay contact, photocell, magnetic pickup, crystal pickup, strain gage or similar transducer.

Atomic Instrument Co., 84 Massachusetts Ave., Cambridge 39, Mass.

CONTINUED ON PAGE 232

HERE'S PROOF: You can always count on Continental for every fastener need!

Only Continental Makes Every Type of Tapping Screw!

. . . to save you time and money

Continental is the only producer making all 14 types of thread-forming and thread-cutting screws. True to their tradition "you can always count on Continental," they have built a reputation of repeatedly meeting every fastener need.

Whether you are interested in specials or standards, Continental's vast stock selection and design know-how are at your service . . . backed by 50 years of experience.

Call today direct or through your local distributor. Let Continental help save time and money in your operation.

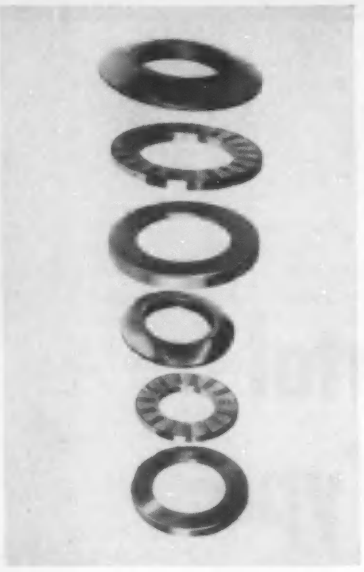
Manufacturers of HOLTITE Fastenings

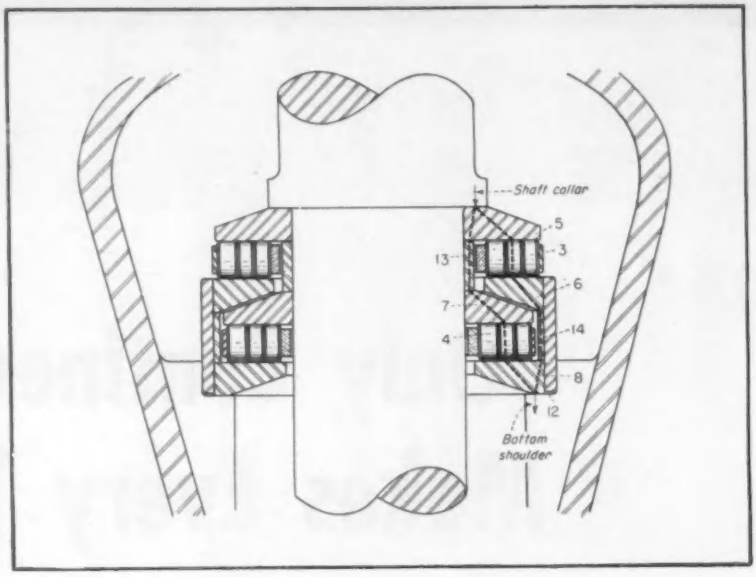
CONTINENTAL SCREW COMPANY INC. 1904

50th Anniversary

CONTINENTAL SCREW COMPANY

New Bedford, Mass., U. S. A.





Tandem Thrust Roller Bearing Has Double Capacity

Because of the bearings in this assembly are seated in tandem along a machine shaft, one above the other, they are said to have twice the thrust capacity and eight times the life expectancy of a conventional thrust bearing. The manufacturers also claim that the new tandem thrust roller bearing assembly generally achieves these results without the basic machine structure in which they will be used being altered in any way. Rather than expanding the housing area of a machine to accommodate the greater diameters of ordinary high capacity thrust roller bearings, the new tandem bearing assembly utilizes axial space along a machine's shaft. Loads as high as 300 tons have been successfully supported by this type of bearing assembly when used, for example, on oil drilling swivel shafts.

Major components of each bearing are: rotatable bearing plate, bronze retainer containing through-hardening steel rollers, a compression sleeve, and a stationary bearing plate.

The outer plate (5) of the raceway for rollers (3) thrusts against the shaft collar, and the outer plate (8) for the rollers (4) thrusts against a bottom casing shoulder (12). The thrust load is transferred from the outer or uppermost bearing plate (5), that is, the first bearing plate, with respect to the downward direction of the thrust, through the bearing plates and rollers, in two paths, one path (follow arrow through shaded area) through compression sleeve (13) to bearing plate (7), roller (4) and plate (8); and the other path (follow arrow through white area) through the rollers (3), the inner bearing plate (6), a compression thrust sleeve (14) to the lower-most bearing (8), which thrusts against bottom shoulder (12). The compression members (13) and (14) are constructed to have the same amount of compression.

Because all of the bearing plates are mounted to accept thrust pressure on their working surfaces, this pressure, in turn, produces a warping action on the plates, bringing their faces, which normally are in planes at a right angle to the axis of the thrust bearing, into a conical formation, while still maintaining them in parallelism.

This deformation taking place along the faces of the bearing plates is said to result in a uniform load along all the rollers in the assembly. Since there are more rollers in the top bearing, it tends to support about 60 percent of the thrust load.

Rollway Bearing Co.,
541 Seymour St., Syracuse 1, N. Y.

AN ENVIRONMENTAL SIMULATION CHAMBER will provide up to 7½ psi positive pressure in addition to automatically controlled temperature-altitude-humidity simulation. Temperatures from 185 F to —100 F can be maintained at altitudes up to 60,000 ft. Other features include automatically controlled relative humidity from 20 to 100 percent, automatic control of pressure, altitudes, and draining of humidity devices below freezing. American Research Corp., Bristol, Conn.

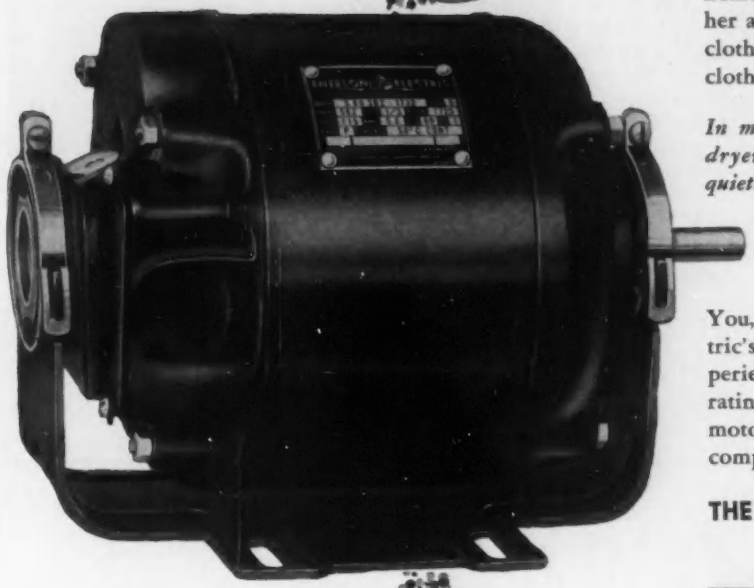
A NEW SINGLE ACTING ROLLER thrust bearing supports a vertical thrust load of 380,000 lb at 16 rpm and has a rated capacity of 700,000 pounds. Differing from most applications of single-acting thrust bearings, no center shaft is used to locate the bearing's roller assembly. Instead, a locating ring, maintains the roller assembly in alignment. The bearing measures 25¾ in. OD, 17 in. ID, and 3¾ in. thick. Rollway Bearing Co., Inc., 543 Seymour St., Syracuse, N. Y.

CONTINUED ON PAGE 234

music to her ears!

A sweet note to the ears of the modern homemaker is the low, efficient hum of her automatic clothes dryer. Clothes lines, clothes pins and a damp basement full of clothes are no longer necessary.

In many of America's best known clothes dryers, an Emerson-Electric motor works quietly and efficiently.



You, too, can benefit from Emerson-Electric's 63 years of motor manufacturing experience. If you require standard motors in ratings from 1/20 to 5 h.p., or hermetic motors from 1/8 to 20 h.p., write for complete information.

THE EMERSON ELECTRIC MFG., CO.
St Louis 21, Mo.

EMERSON - ELECTRIC'S unique
Twin-gineering
SERVICE
solves your power problems

Our engineers are eager to work with yours in designing and providing the correct motor for contemplated new or improved appliances or equipment. "TWIN-GINEERING" saves costly engineering "back-tracking," and may suggest short cuts and product improvement. Write today for Bulletin No. 489.

EMERSON ELECTRIC
MOTORS • FANS APPLIANCES

Desk-Top Analog Computers Replace Large Units

Said to be the first desk-top electronic analog computers suitable for research laboratory or office use, the unit shown in the illustration measures only 20 by 25 by 20 inches in size, and is capable of replacing conventional computing equipment that normally occupies a seven-foot cabinet.

The new desk-top computers can solve differential equations, or simulate physical systems, up to the sixth order of magnitude. All mathematical operations are performed with better than 0.1 percent accuracy. Computing elements are matched to close tolerances and are said to be exceptionally stable.

Models C301 and C302 are completely self-contained, with built-in supplies for amplifier and relay operations and an internal computing reference source. Problems are set up on patch boards which plug into the front of the computer, and the row of dials are properly set at the top. The answers are read off the strip chart at left. Thus one computer can be used for several problems and by different operators in success with minimum set-up time. External equipment can be wired into problems through binding posts and connectors so that a desk-top computer can be interconnected with other computers of any size. With an auxiliary kit, these units can be operated as repetitive computers, permitting solutions to be displayed on a standard cathode-ray oscilloscope.

Models C301 and C302 each contain 12 individually chopper-stabilized computing amplifiers identical to those used in the full-size analog computer made by this company. These amplifiers have low noise drift of less than 0.25 millivolts per day, d-c gains of over 15 million, and full load current over an output voltage range exceeding ±100 volts. Automatic true overload indication is provided for each amplifier.

REAC C301 has all components wired directly to the patch bay, affording great flexibility. Problem control is obtained by patching computing elements through switches and relays.

REAC C302 has a completely integrated built-in problem control system, so that patching and operating of problems is the same as in the large computers. This model is intended for the industrial and research laboratory.

Reeves Instrument Corp., 215 E. 91st St., New York 28, N. Y.

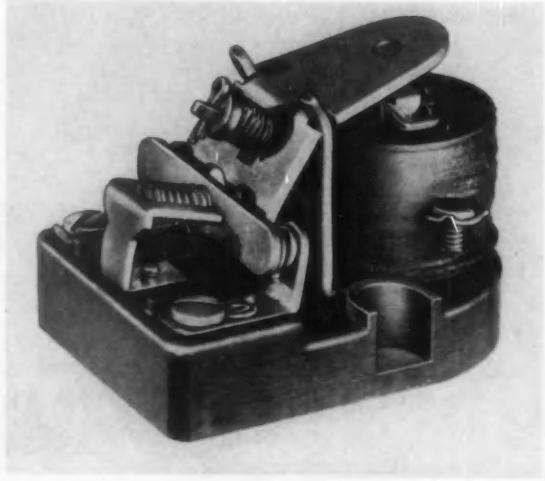
New Relay for Capacitor Start Motors

This new compact magnetic relay is designed for use with single phase capacitor start motors requiring a voltage-sensitive relay to disconnect the start winding or reduce the capacitance when the motor approaches full speed.

Assembled on a molded phenolic base, the device measures only $2\frac{1}{16}$ in. high, $1\frac{3}{16}$ in. wide, and $2\frac{1}{2}$ in. deep. The clapper-type magnet is designed with a permanent air gap, a knife-edge bearing, ground sealing surfaces and a heavy shading coil, to provide long life and quiet operation.

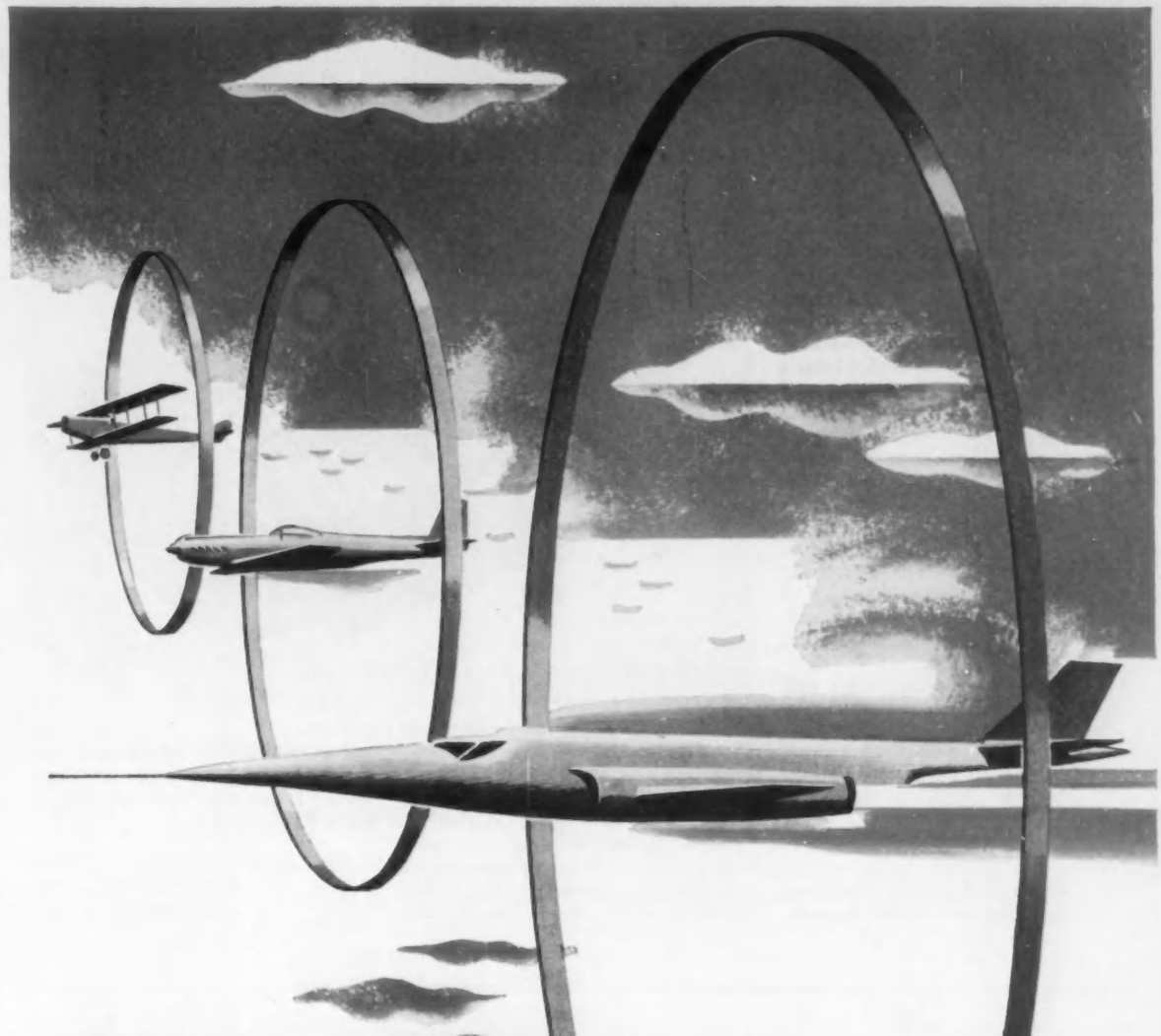
Double break, silver-to-silver contacts on the single pole, normally-closed relay are capable of handling start winding currents up to 50 amp on 115 volt motors, and 35 amp on 230 volt motors. Magnet coils are available for continuous duty ratings up to 480 volts, 60 cycles or 300 volts, 25 cycles.

Relay pull-in voltage is adjusted at the factory for operation within the desired range. For further information on this and other relays, write to the manufacturer.



Square D Co., 4041 No. Richards St., Milwaukee, Wis.

CONTINUED ON PAGE 236



The shape of rings to come

It is difficult to predict the shape tomorrow's air power will take. But one thing is certain — fabrication of many of the component parts, such as rings, bands, and the complicated assemblies will be accomplished by welding.

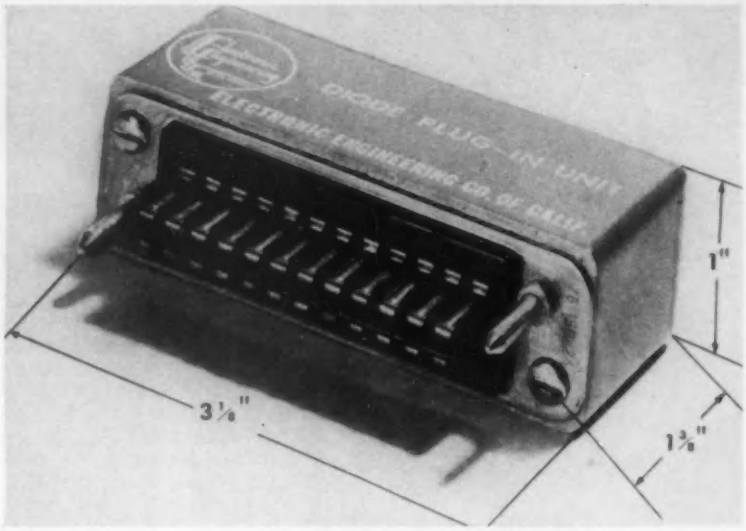
If a new alloy — a special metal — an intricate assembly pose a problem to design or manufacture perhaps our specialized knowledge gained in 35 years of welding fabrication can help to find a practical and economical solution. Our Product Development Division will be glad to put experience gained from working with every major U. S. jet engine manufacturer to work for you. In addition to fusion and resistance welding of ferrous and non-ferrous metals, American Welding can provide designing, engineering, metallurgical and machining facilities.

Write us today for complete details
140 Dietz Road • Warren, Ohio

THE AMERICAN WELDING & MANUFACTURING COMPANY • WARREN • OHIO

Diode Plug-In Unit Has Many Applications

Designed for diode matrix, mixer, computer circuits, and similar multiple applications, the new plug-in diode units like the one shown will accommodate either 12 or 16 germanium diodes. The new multiple plug-in diode unit provides a rapid means of inserting and removing diodes from a circuit, plus the added advantage of having them encased in a dust-proof, moisture-resistant package. Manufactured in two sizes to accommodate either 12 or 16 germanium diodes, the multiple unit's seated dimensions for the 12-diode plug-in are: length, $3\frac{1}{8}$ in.; width, 1 in.; height, $1\frac{3}{8}$ inches. Dimensions for the 16-diode unit are identical except for length which is $3\frac{11}{16}$ inches. The multiple unit is fabricated of cast aluminum and is finished in a baked gray enamel.



The construction of the plug-in unit is such that the plug to which the diodes are soldered can be easily removed by loosening two screws.

Correct polarization of the germanium diodes is assured by means of special guide pins which prevent the plug from being inserted incorrectly in a circuit.

The new unit has a large number of applications and can be used to package clippers, limiters, d-c restorers, modulators or demodulators, second detectors, ring circuits, bridge circuits, rectifiers, and diode gates. It also has possibilities for packaging items used in fire control equipment, and special development equipment. An added advantage is that down time for the unit is reduced because the backward and forward resistance of each diode can be tested by simply plugging it into a testing device.

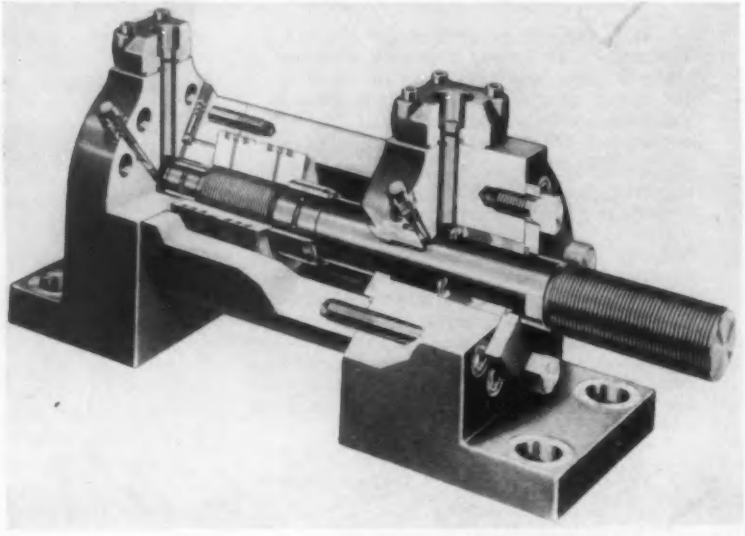
Electronic Engineering Co. of Calif.,
180 *South Alvarado St.,*
Los Angeles 57, *Calif.*

New Line of Hydraulic Cylinders

Features of the new line of hydraulic cylinders include heavy duty construction, spring loaded piston rod packings, and mounting design making them interchangeable.

The cylinders are available with male or female, single or double end piston rods, with combinations of mountings. In the 2,000 and 3,000 series there is a choice of standard or 2:1 piston rods. Bore sizes in the standard line are from $1\frac{1}{2}$ to 12 in.

The model 300 series cylinder line is designed for 150 psi air or 300 psi oil hydraulic service. The 2,000 series cylinders and 3,000 series cylinders are designed and built for 2,000 psi and 3,000 psi oil hydraulic service respectively. Shown is a cutaway of one of the 3,000 psi oil hydraulic series.



The Hydraulic Press Mfg. Co.,
Mount Gilead, Ohio

CONTINUED ON PAGE 238

LARGE SIZES AND
INTRICATE SHAPES
CAN NOW BE FORGED
The press forgings produced by Cameron approach for the first time the broad field of intricate shapes and patterns that have been limited heretofore to steel castings. Thus, the many manufacturing advantages of steel forgings are made more widely available. These advantages include controllable grainflow characteristics and a uniformly high quality, free from internal defects such as porosity and inclusions.
The Cameron forging process opens the door to a great many design features which will aid in producing equipment of greater utility and at a lower cost in manpower and material.
FORGE AND ORDNANCE
DIVISION
Cameron
IRON WORKS, INC.
HOUSTON, TEXAS
Scale
one foot

Self-Contained Hydraulic Power Units

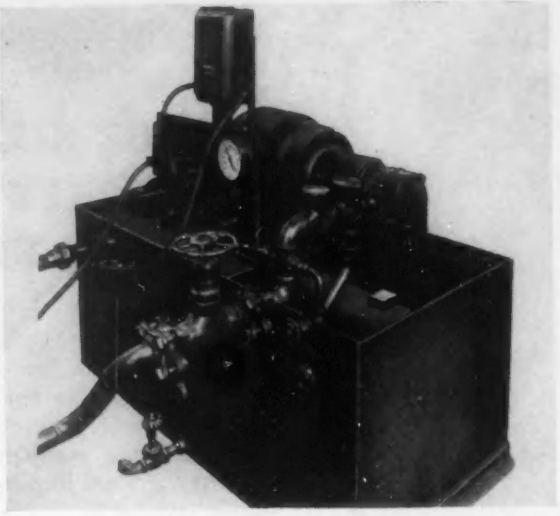
Self-contained power units for the operation of oil hydraulic equipment, either individually or in groups, are now being made available in a range of capacities from 7 gallons to 54 gallons per minute oil consumption or delivery of pressures of 200 to 1,000 psi. Horsepower ranges from 7½ to 30 for these oil deliveries.

Finger tip adjustment of line pressure is possible on the power units, and all piping and fittings are of high pressure steel and welded in the joints with flange connections to valves and pump to facilitate quick removal for repair.

Each unit has magnetic starter, push-button control and each is factory-wired. The motor and pump are direct-connected and flange-mounted insuring accurate alignment.

The power unit pumps are completely unloaded when the pressure setting is reached, and do not pump against a pressure head or relief valve. This feature adds to long pump life and low power consumption, according to the manufacturer.

Rapid operation of equipment is possible with the 2-inch pipe delivery and return. The unit is complete with reservoir, accumulator (nitrogen charging inlet valves and bottle connections), baffled type oil cleaner, automatic water cooling, with all of the electrical switching gear with overload protections, and 2 inch high pressure shutoff valve.



Harvill Mfg. Co., Harvill Bldg., Corona, Calif.

Precision, Snap Action, One-Way Impulse Switch

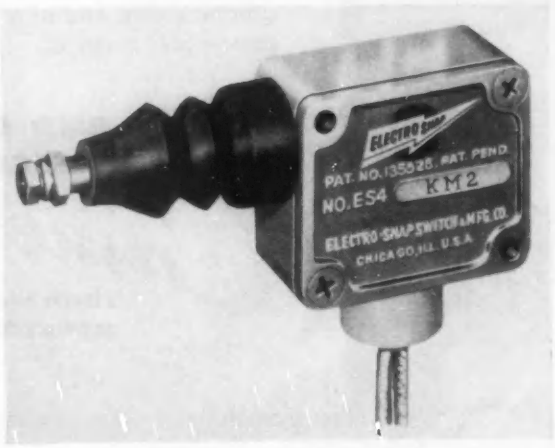
The manufacturers of this new precision, snap-action switch featuring one-way impulse action claim that it opens new possibilities in simplified economic circuitry, and will give good control performance.

This model ES4-KM2 switch frequently eliminates the need for time delay relays, complicated actuating dogs and additional switches. For example, in a switching operation where a pulse to a solenoid or starter is needed, the switch sends the controlling electrical impulse and then drops completely out of the circuit. This allows the solenoid valve to return after it receives an electrical impulse from the circuit controlling the return solenoid.

In this new ES4-KM series, there is a choice of five "on" periods; from $\frac{1}{16}$ to $\frac{3}{8}$ inch. The switch completes the circuit for a pre-determined part of the plunger's forward stroke; then gives release to the impulse as the plunger advances. No further action results for the remainder of the plunger's over-travel or return stroke.

High electrical capacity, long contact life and a double-break contact provide two separate circuits offering many application advantages. A few of the many, effective applications include: control of automatic sequence movements; safety interlocks; positioning switches; limiting action of machine members; pulsing electrical counters; and initiating time cycles.

This die-cast snap-action switch is small and light weight. The actuator plunger is completely sealed by a neophrene boot to keep out water, oil, dust and other foreign elements. The boot retains its flexibility at temperatures between —67 F to +160 F. For extreme temperatures, special silicone boots are available. These boots are easily replaced without tools.

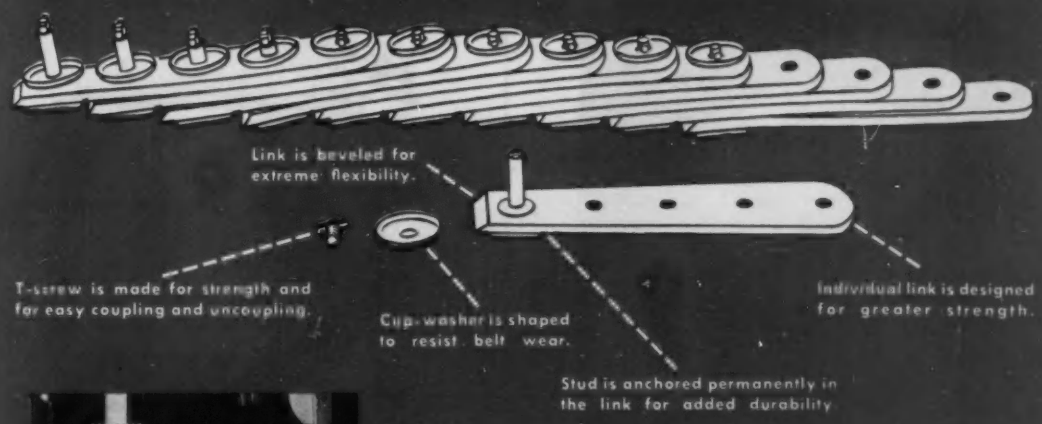


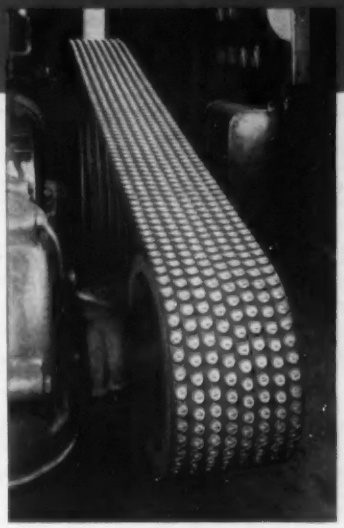
The basic model ES4-KM2 switch is a single-pole, double throw type for alternating current circuits. There is a choice of wiring which includes: single-pole double throw; two circuits, normally-open or normally-closed.

Electro-Snap Switch & Mfg. Co., 4218-30 W. Lakes St., Chicago 24, Ill.

CONTINUED ON PAGE 240

This detailed line drawing of the new, patented Veelos TD and TE v-belt makes it easy to see how this new v-belt is designed to do a better job . . . easier!


Link is beveled for extreme flexibility.
T-screw is made for strength and for easy coupling and uncoupling.
Cup-washer is shaped to resist belt wear.
Stud is anchored permanently in the link for added durability.
Individual link is designed for greater strength.



New VEELOS

TD and TE Adjustable V-belt

So easy to couple *it installs in minutes*

So strong and durable *it lasts for years*

The new Veelos TD and TE adjustable v-belt is the successful development of a specific v-belt designed for a specific service—D and E drives.

This new Veelos TD and TE v-belt has these basic advantages . . .

It simplifies installation. Links are quickly joined by easy-to-use cup-washers and T-screws to make up individual belts. It's the easiest v-belt to couple and uncouple ever developed. And you don't need to waste time removing outboard bearings.

It lasts longer—is more flexible. New high-tensile strength link combined with new stud, cup-washer, and T-screw gives added durability. New link construction provides maximum flexibility for cooler, wear-resistant running.

Get the complete story of this great new v-belt for D and E drives. Send coupon now for new 8-page illustrated catalog.

VEELOS
THE 'LINK
V-BELT

Veelos is known as Veelink outside the United States.

MANHEIM MANUFACTURING & BELTING CO.
610 Manbel St., Manheim, Pa.

Please send copy of your new Veelos TD and TE v-belt catalog.

Name .....

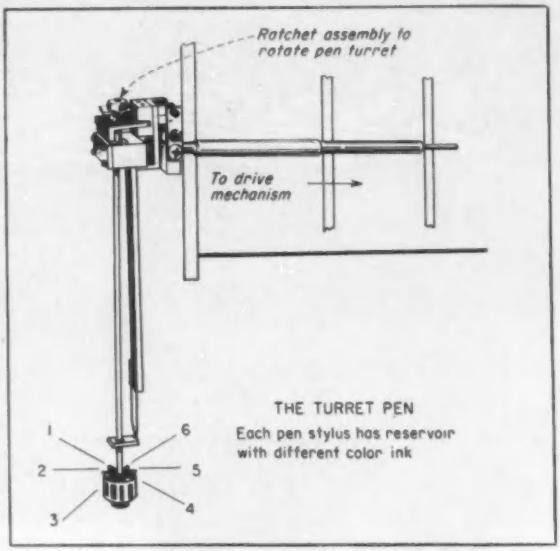
Company .....

Address .....

.....

201

ADJUSTABLE TO ANY LENGTH • ADAPTABLE TO ANY DRIVE



Recording of 96 Separate Points On One Chart

Capable of gathering operating data from 24 separate sources and logging the collective information on a single circular chart, both the new Tektolog and Null Balance recorder will provide accurate measurement for many industrial process and laboratory applications. Through a segmental chart drive unit, the instrument becomes either a 24, 48, or 96 multi-record system. These instruments can be directly coupled to tachometers, resistance thermometers, conductivity cells, strain gages, carbon dioxide indicators, pH meters, and the like, to produce a permanent record.

Recording in either instrument is achieved through a six-point turret pen mechanism which traces six different colors. By dividing the standard circular chart into four equal parts and installing a mechanism to rotate the chart periodically, data from six separate points can be logged in each quarter. A standard synchronous chart drive motor keeps the chart in time, so that each quarter of the chart may be made to correspond to a 1 hour, 8 hour, 24 hour, or 7 day period. The print cycle is 5 seconds per point and the total cycle for all 24 points is only two minutes. A convenient feature allows the cycling mechanism to be switched off, permitting the unit to operate as a standard single-point pen inking recorder.

The segmental chart drive unit is a motor driven assembly to produce intermittent motion to the chart hub. It rotates the chart through a fixed angular rotation, once for each print cycle of 6 records. Thus, it is possible by rotating the chart through a 90 deg angle, to print on each of 4 segments, 6 records in each chart segment. This assembly is a self-contained unit which can be added to the basic 6 point instrument.

The segmental mechanism provides a multi-point recorder, printing 24 individual records on a standard size circular chart. When the segmental indexing mechanism is reduced to an angular movement of 45 deg, the result is 8 individual segments on a circular chart, permitting the plotting of 48 individual records on a single chart. This can be increased to 96 or more points by reducing each segment on the chart to 22½ deg or less.

The tektolog is accurate to plus or minus 1 percent of full scale and features a sensitivity of 0.1 percent with a reproducibility of plus or minus 0.5 percent. Inputs range upwards from 50 micro-amps d-c and 30 millivolts d-c. It can be used to record almost any electrical quantity.

The null balance instrument is particularly suited to resistance bulb thermometry, conductivity measurements, displacement with strain gages or linear differential transformers, capacity measuring devices, 3 wire telemetering devices, and the like. In the field of thermometry, a selection of nickel bulbs and fittings is available for use with temperatures up to 600 F, and a selection of high temperature bulbs and fittings to 900 F. Standard calibration ranges are supplied, and with platinum and other high temperature bulbs, the range covered can be extended.

Fielden Instrument Div., 2920 N. 4th St., Philadelphia 33, Pa.

AN IMPROVED PULSATION DAMPENER to be installed on gauge and governor lines has been redesigned to a shorter length and equipped with a filter of stainless steel to prevent corrosion. The body is all brass for 3,000 lb operating pressure, or steel with stainless steel micro-valve for 6,000 lb or all stainless steel for 10,000 pounds. Called the Micro-Bean, the valve has a 96 to 1 taper to eliminate stem and screw compression strain, and is now produced with both female threads, ¼ or ½ inch. J. A. Campbell Company, 645 E. Wardlow Road, Long Beach 7, Calif.

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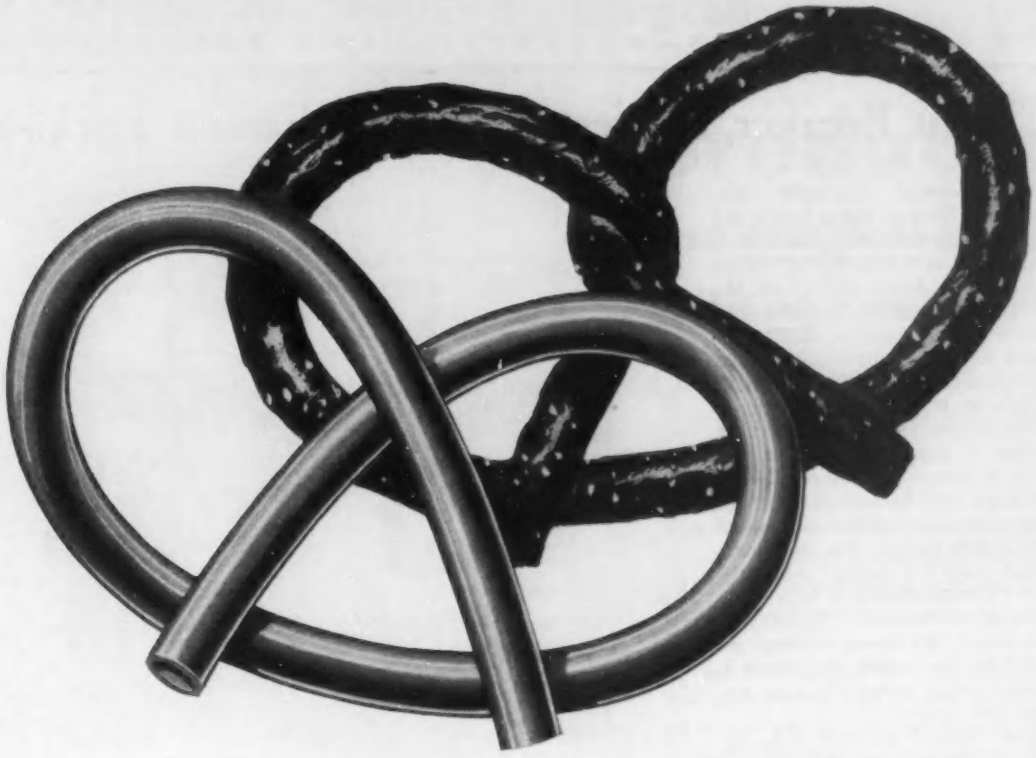


what's a pretzel got to do with tubing?

Just this—like a pretzel baker, OSTUCO is a specialist in bending, too! But it is only one of OSTUCO's many versatile facilities for manufacturing, fabricating, and forging. You'll always find OSTUCO a dependable *single source* for both carbon and alloy steel tubing, and its quality is strictly controlled from raw materials right on through to prompt shipment to you. If you're presently using tubing or if you're considering its use in your product, write for our newest catalog, "OSTUCO TUBING." Better yet, send us your blueprints for a quotation. OSTUCO's engineering and design staffs are always available to work with you on problems concerning tubing.

By the way, did you know that Shelby, Ohio was the birth place of the seamless steel tube industry in America?

OSTUCO SHELBY, OHIO **OSTUCO TUBING**

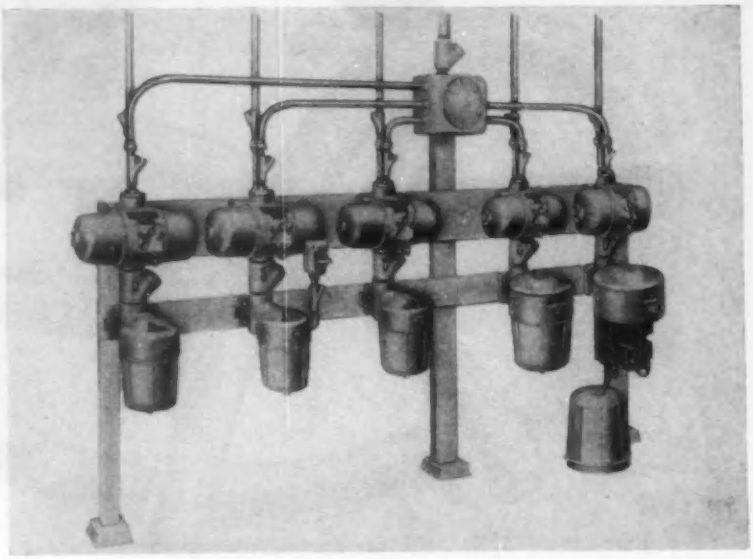
SEAMLESS AND ELECTRIC WELDED STEEL TUBING
—Fabricating and Forging

OHIO SEAMLESS TUBE DIVISION
of Copperweld Steel Company • **SHELBY, OHIO**
Birthplace of the Seamless Steel Tube Industry in America
SALES OFFICES: BEVERLY HILLS • BIRMINGHAM • CHARLOTTE CHICAGO • CLEVELAND • DAYTON • DETROIT • HOUSTON LOUISVILLE • MOLINE • NEW YORK • PHILADELPHIA PITTSBURGH • SALT LAKE CITY • ST. PAUL • SEATTLE SYRACUSE • TULSA • WICHITA
CANADA, RAILWAY & POWER CORP., LTD.
EXPORT: COPPERWELD STEEL INTERNATIONAL COMPANY 117 Liberty Street, New York 6, New York

Circuit Breaker, Starter, And Combination Enclosure

Explosion-proof, dust-tight, rain-tight circuit breaker, motor starter, and line starter combination enclosures, are available in a new line called the Unilets. With a new sealing unit, the enclosures, those shown, may be joined in combination in certain sizes.

Each component for circuit breaker, motor starter, and seal has full 7-thread engagement at the coupling joints as well as on the bolt-free covers. Safe entranee to individual motor starters for maintenance work is possible in both single and banked combinations in hazardous areas without shutting off other branch circuits. No live circuit breaker wires are exposed while the motor starter enclosure is open on a line starter combination. The manufacturer claims that money savings are effected by this feature, since there is no unnecessary "down time" on machines and equipment.



Other features include: U.L. approval on banked circuit breaker unilets up to groups of three for Forms 1 and 2; lightweight construction for easy installation without use of heavy lift equipment; standardized mounting frames for interchangeability of most well-known makes of circuit breakers and motor starters in certain sizes; simplified straight-thru wiring; versatile hub adaptors which permit use of over-size conduit and conductors; and push-button and pilot-duty control. Shown in the illustration is a view of four circuits safely operating under hazardous conditions while the fifth motor is exposed for maintenance work. With this design, no down time is required for the other equipment.

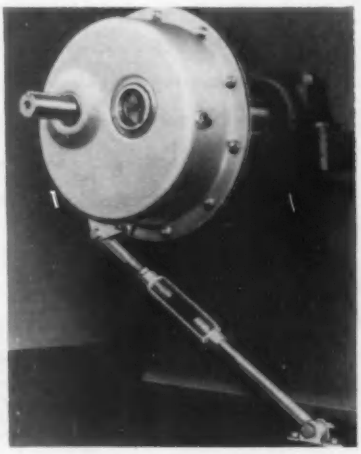
The new unilet line covers all breaker-started control equipment of most manufacturers rated to 225 amp breaker loads, and to 100 hp on 3-phase induction motors at 600 v maximum. More information may be obtained from the manufacturer.

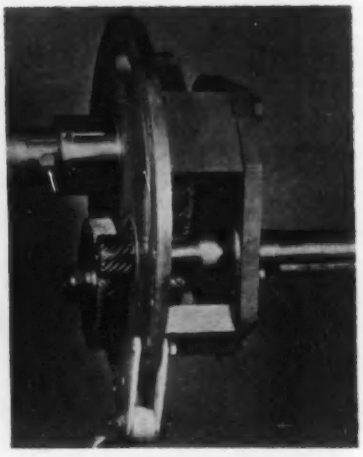
Appleton Electric Co.,
1701-59 *Wellington Ave., Chicago* 13, *Ill.*

Shaft Mounted Speed Reducer Requires Little Space

This new speed reducer mounts directly on the shaft to be driven, and requires no floor space other than that needed for the motor and tie rod connection. The tie rod is fastened to the outer rim of the housing, and the movement of the input shaft varies in proportion to its radial distance from the hollow shaft. The average belt tightening distance is approximately one-half of the distance traveled by the tie rods in the turn buckle.

Adapted to various diameters, this drive features high ratios of speed reduction in limited space. A choice of single or double reduction unit makes possible the selection of almost any output speed between 420 and 14 rpm, merely by changing sheave sizes within allowable limits. Six sizes available in the range from ½ to 30 hp.





The Falk Corp., 3001 W. *Canal St., Milwaukee* 8, *Wis.*

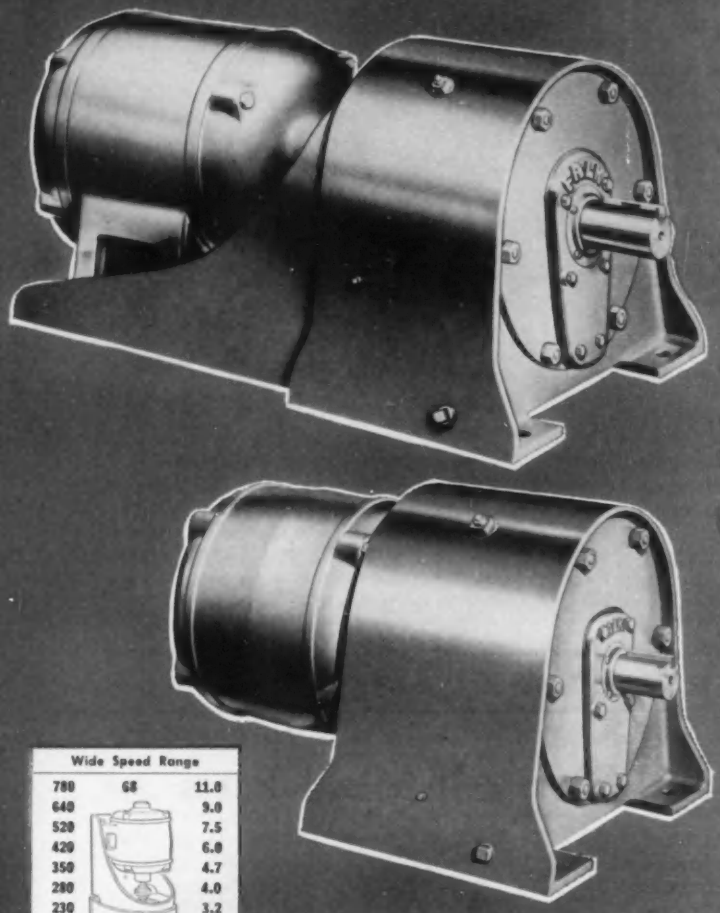
CONTINUED ON PAGE 244

Both... All-Motor and Integral

ALL-STEEL FALK Motoreducers

use *complete* motors with *no* modifications

...another important reason why you should consult FALK!

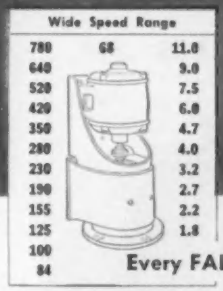


Your customers never have the annoying problem of motor modification when you standardize on *all-steel* FALK Motoreducers. Both the universally popular All-Motor type and the newly redesigned Integral type use *completely standard motors without modification.* The motor can be quickly and easily replaced by another standard motor of any make, type or speed within the unit's AGMA rating when necessary without disturbing the reducing unit.

Many choose the All-Motor type because it permits easy interchange of motors, or even *parts,* on the job, *in minutes*—with a minimum of down time. Others like the new Integral type with standard D-flange NEMA motor because it is a highly compact, streamlined unit providing the utmost in space economy.

In every FALK Motoreducer—All-Motor or Integral—the output speed (ratio) can be changed within the unit's torque capacity without modifying the motor.

Both types contribute to your industrial equipment all the quality, adaptability, dependability and long-range economy for which FALK has been celebrated for more than sixty years. FALK Motoreducers are available in standard ratio for stock shipment. Write to Dept. 247.



Every FALK Motoreducer has these "In-built" Factors—

Wide Speed Range. Selective ratio combinations provide output speeds from 1.5 rpm to 1430 rpm with stock gears.

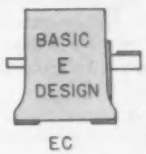
Sealed Housings. Dual closures and one-way vents keep oil *in,* dust and moisture *out.* Units are splash-proof, leakproof, dustproof.

Precision Gearing. Heat treated alloy steel, precision cut and shaved helical gearing throughout . . . quiet-operating crown shaved pinions . . . taper bored gears for easy ratio changes.

All-steel Housings. Unbreakable, strong, rigid. Generous overhung load capacities provided by wide bearing spans, large shafts and bearings.

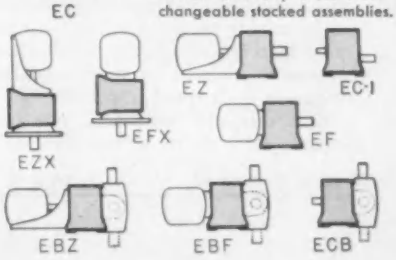
Streamlined inside and outside. Smooth, clean surfaces; machine welded construction conforms to NEMA motor frames.

Positive Lubrication. Large sump capacity . . . oil-tight construction assures clean lubricant . . . direct dip of revolving elements provides positive lubrication at all speeds.



EC

The basic E design permits maximum use of standardized parts . . . closer control over materials, processing, inspection and assembly . . . resulting in faster delivery from interchangeable stocked assemblies.



FALK ...a good name in industry

THE FALK CORPORATION 3001 W. Canal St. Milwaukee 8, Wis.

WRITE TO DEPARTMENT 247

Two, Three, and Four-Way Solenoid Valves

Electrical operation of an entire line of 2-, 3,- and 4-way valves in ⅛ thru ½ NPT sizes, is now possible through the development of a new solenoid actuating device.

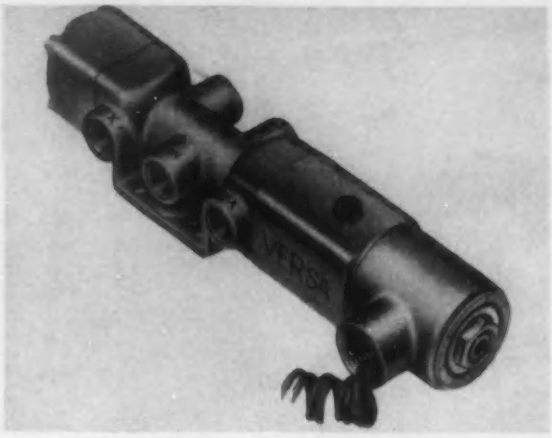
This solenoid is of the secondary pilot operating type in which a relatively small solenoid controls a pilot cylinder in the valve, to provide the force for shifting the valve spool. This solenoid cylinder method of actuation is claimed by the manufacturer to be more dependable, safer, smaller, faster, lighter and less expensive to operate than direct solenoid actuation.

These valves will handle a variety of actuating devices. The new solenoid valves may be repositioned by spring return or by any of the other actuating devices among which are hand, cam, pilot and foot, or a second solenoid may be used for this purpose.

Four-way double solenoid valves may be spring centered, (neutral position) with many arrangements of the pressure spools which control the flow. For example, all ports closed in neutral, exhaust open in neutral, and inlet open in neutral are a few of the standard arrangements.

No additional line is required for the solenoid pilot cylinder when the solenoid valves are used for pressures up to 150 psi, since these valves are internally drilled to supply main line air or fluids to the solenoid pilot. For controlling hydraulic pressures over 150 psi up to 500 psi, an auxiliary low pressure line of 35 to 150 psi is needed to supply the solenoid pilot.

All internal parts are interchangeable in the 2-, 3-, and 4-way types, and the valves can be completely serviced or



disassembled without disturbing pipe connections.

Among the features of the valve is the anti-extrusion arrangement of all the kinetic O-ring seals in each valve type. This makes it impossible to cut the seal rings in the normal operating pressure range. These valves have threaded ports. The transverse flow area in all types and sizes correspond to the pipe size of the valve.

Versa Products Co., Inc., 249 Scholes St., Brooklyn, N. Y.

Instrument Tests and Sorts All Metal Parts

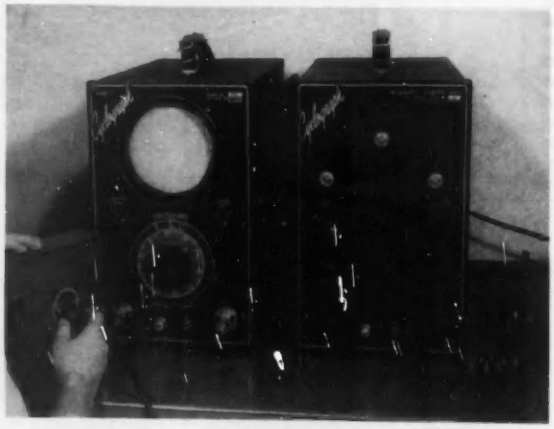
Non-destructive testing and sorting of accidentally mixed or incorrectly processed metal parts can be done quickly by the new model C-1 cyclograph shown. The instrument can be used on either ferrous or non-ferrous metals, and will sort raw stock, semi-finished, or finished parts by their metallurgical characteristics such as analysis, hardness, structure, case depth, and so forth.

With a known and acceptable part used as a standard in adjusting the instrument, unwanted parts are separated from the good ones.

The model C-1 Cyclograph can be used as a hand sorter, in which case the operator watches the screen and manually throws out the off-standard parts, or it can be used in conjunction with a type 407 automatic relay unit. The relay unit eliminates operator discrimination and permits sorting of more thousands of parts per day. Parts can be passed through the test coil on a belt conveyor or by other fast feed means.

The relay unit sends out a reject signal whenever an off-standard part passes through the test coil, and this signal can be used to operate a solenoid operated reject gate, paint spray marking device, or other reject means. The combination is claimed by the manufacturer to permit fully automatic, high speed inspection.

With this new instrument, size and shape of this part presents no problem, as test coils are wound for any size

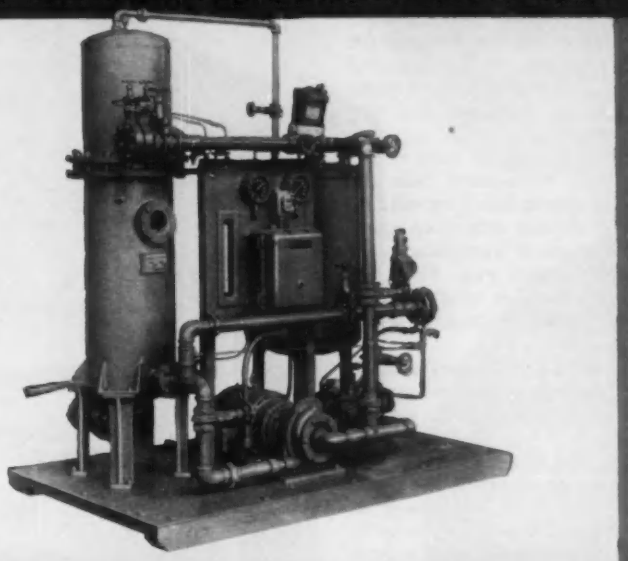


opening desired. Typical parts that may be inspected are: bolts, nuts, screws, aircraft valves, roller bearings, AP shot, jet engine rotors, blades and other forgings, malleable castings, welding rod, automotive parts, steel and copper tubes, piston rings, ordnance items, bar-stock.

J. W. Dice Co., 1 Engle St., Englewood, N. J.

CONTINUED ON PAGE 246

HOW TO FILTER WATER FOR OIL RECOVERY



Crane Wedge Disc Clamp Gate Valve . . . extra strong, extremely compact. Clamp design is ideal where easy cleanout may be required. Bonnet assembly and disc lift out —body stays in the line. O.S. & Y., inside screw, and quick-opening patterns, all-iron or brass trimmed. Screwed or Flanged ends. Sizes up to 4 in. Working pressures up to 150 psi saturated steam, 225 psi cold service.

another successful product design with piping equipment by CRANE

Water flooding for oil takes a lot of specialized water treating equipment. A prominent supplier is R. P. Adams Co., Buffalo, N. Y., whose field test filter unit for secondary recovery is shown here.

The Adams design provides permanent filter mediums and permits easy backwashing without disassembly. Built for rugged service, the unit is equipped with Crane piping materials for added dependability.

Dependability is the big reason, of course, why more and more design engineers specify from the familiar Crane Catalog. But they also know that here is a reliable source of valuable piping information. For each piping item, Crane provides the data you want . . . sizes and dimensions, temperature and pressure ratings, plus a run-down on materials and construction. Fully indexed, of course, to save you time.

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THE BETTER QUALITY... BIGGER VALUE LINE... IN BRASS, STEEL, IRON

CRANE VALVES

CRANE CO., *General Offices:* 836 S. Michigan Ave., Chicago 5, Illinois
Branches and Wholesalers Serving All Industrial Areas

VALVES • FITTINGS • PIPE • PLUMBING • HEATING

Automatic Wet Blaster Speeds Small Parts Cleaning

Known as the pressure blast roto-matic, this new automatic model in wet-blasting equipment was designed for the elimination of hand filing, grinding, wire brushing and chemical cleaning of small metal parts such as castings, forgings, machined items, stampings, extrusions, and various plastic and ceramic components.

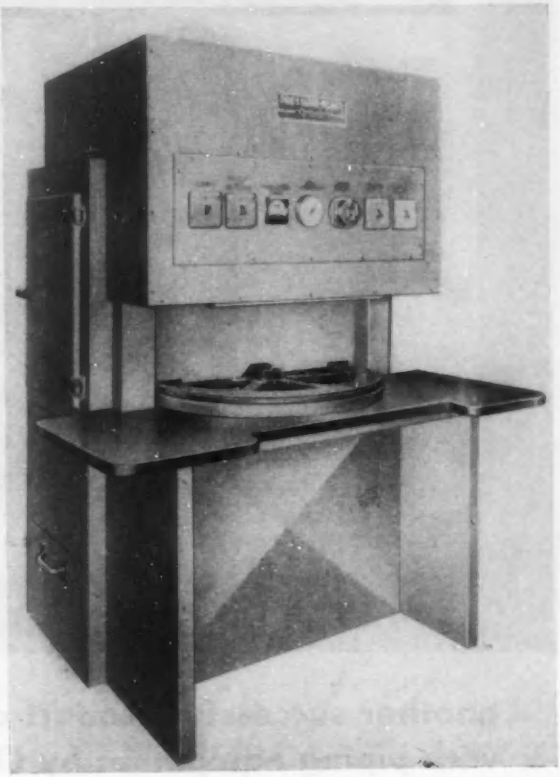
In operation, the operator is seated at the front of the unit and only loads and unloads work-pieces from the rotating table which incorporates appropriate work holding fixtures. The cabinet interior is divided into three chambers accessible from all sides by means of inspection doors: the blast chamber where fixed position guns finish the work in part or entirely; the rinse chamber where abrasive slurry is rinsed from the work; the air-dry chamber where the work pieces are dried.

A readily accessible panel contains all necessary controls for operation. Included is a variable speed table drive regulator which governs the exact amount of time the work is to be blasted.

Because of its flexible design, the new machine may be used for any number of finishing operations where speed and uniformity are required. The only requirement in switching from one type of work to another is a change in work holding fixtures, and a re-positioning of the blast guns. An advantage of this unit is that more guns may be added at any time.

Made of stainless steel throughout, no pumps or mechanisms of any kind are employed in the blast system. Two blast circuits are available, either regular velocity which works on the aspiration or suction principle, and high velocity which operates on the pressure tank system.

The Cro-Plate Co., Inc., 747 Windsor St., Hartford 5, Conn.

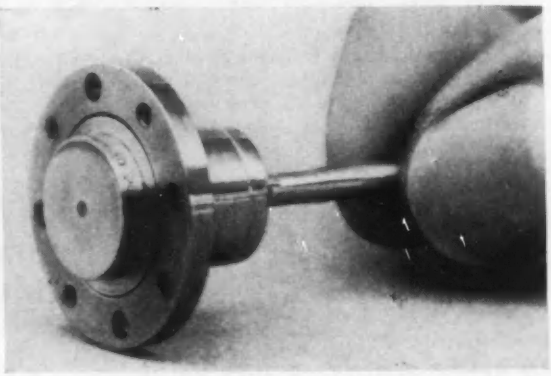


Miniature, Flush-Type Diaphragm Pressure Pick-Up

Where pressure transients occur too rapidly for observation with conventional indicating devices, the new electrical resistance-type 4-312 pressure pickup shown gives immediate response to pressure changes. This latest in the line of miniature pickups is available in gage, absolute, and differential models which feature high corrosion resistance and a flush-type diaphragm. It may be used for either liquid or gaseous measurements.

Absolute models are available in 10, 15, 25, 50, 100, and 150 psia ranges. Differential models are supplied with ranges ± 5, ± 7.5, ± 12.5, ± 25, ± 50, and ± 75 psid, and are usable with maximum line pressures of 150 psi. Upper limits of gage pickups are 5, 10, 15, 25, 50, 100, and 150 psig. The pickup weight is 20 grams. Diameter and length are 0.5 by 0.75 inch.

A variable-resistance unit incorporating a 4-arm bridge, the model 4-312 converts changes of pressure against the diaphragm to proportional changes in voltage output. Output can be recorded with an oscillograph. Overloads to 250 percent of full scale can be tolerated without damage. Hysteresis and linearity held to ± 1 percent full scale above 5 psi, and less than ± 2 percent below 5 psi.



Since either a-c or d-c may be used for excitation of the internal bridge, these pickups can be used in a variety of controlling, indicating, and telemetering applications.

Consolidated Engineering Corp., Pasadena 15, Calif.

CONTINUED ON PAGE 248

Dead weight means less freight for truckers...

So Trailmobile **saves 140 pounds** on "props" with **ALUMINUM INDUSTRIES** Castings

● Famous Trailmobile Trailers are engineered in minute detail to obtain the highest possible strength-to-weight ratio. In keeping with their strong, lightweight aluminum bodies, quarter panels and structural members, Trailmobile uses aluminum "props" that are sand cast in the foundries of Aluminum Industries, Inc.

These Permite aluminum castings have the structural soundness and high strength to support heavy loads, yet weigh but *30 pounds each*. That's a clean saving of 140 pounds of dead weight on the two "props" . . . important to the truck driver who must raise the "props" up into traveling position before getting underway . . . important to the truck owner because every pound of dead weight saved gives him extra payload.

Why not check over the components of your product? Perhaps there are parts which could be cast in aluminum by Aluminum Industries, Inc., to give *you* a lighter, more efficient assembly — or a more attractive, more saleable product. Recommendations by Aluminum Industries engineers have helped manufacturers in widely varying fields to obtain these objectives.

Recommendations and cost estimates on your parts requirements are yours for the asking.

ALUMINUM INDUSTRIES, Inc.
CINCINNATI 25, OHIO
Chicago: 64 E. Jackson Boulevard
Detroit: 809 New Center Bldg. New York: 9 Rockefeller Plaza

PERMITE Aluminum Castings

ALUMINUM PERMANENT MOLD and SAND CASTINGS . . . HARDENED, GROUND and FORGED STEEL PARTS

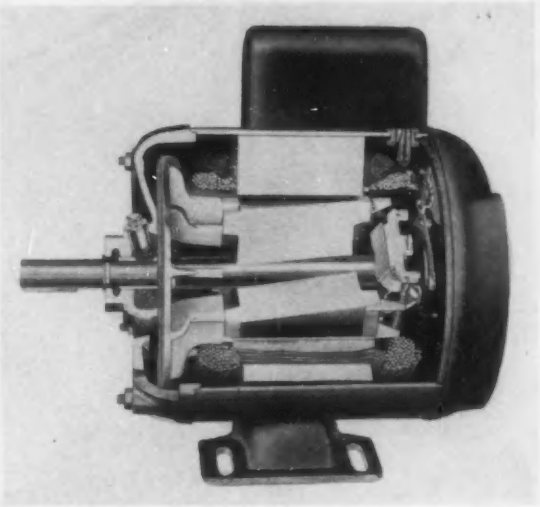
New Line of Fractional Horsepower Motors

Known as the form F, a new line of open type, drip-proof fractional horsepower motors in the rerated design are available in such models as the type SP split phase single phase induction motors for general purpose applications where the load is easy to start and easy to pull up to speed. Type CS—capacitor start single phase induction motors for hard to start applications such as pumps, compressors, and machines starting loaded. Type SC—squirrel cage polyphase (3 or 2 phase) induction motors for all general purpose applications.

Ratings of the new motors are $\frac{1}{6}$, $\frac{1}{4}$, $\frac{1}{3}$, $\frac{1}{2}$, $\frac{3}{4}$, and 1 hp.

Some of the features are: a high pressure, die cast aluminum squirrel cage rotor, with a large capacity cluster type fan cast integral with the rotor winding. The large fan is shown on one end of the rotor, with the smaller fan on the other end used for the $\frac{1}{4}$ and $\frac{1}{3}$ hp ratings. The $\frac{1}{4}$ and $\frac{1}{3}$ hp use the smaller fan on both ends. Phosphor-bronze sleeve bearings are used. The governor has equalized actuating pressure in operating the switch because of the yoke design that contacts the governor plate.

Century Electric Co., St. Louis 3, Mo.

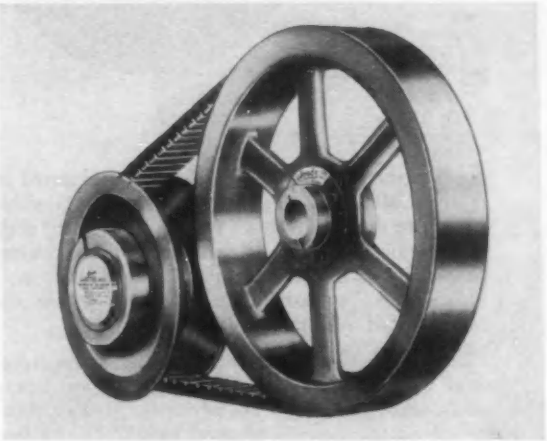


Variable Speed Drive Unit

Just added to a complete line of mechanical power transmission equipment is a new variable speed drive unit that is said to incorporate many new features.

Features such as: a wide speed range, up to 3 to 1 speed range ratio; horsepower range, new notched belt construction gives higher horsepower capacity for single belt drive 5 to 20 horsepower motors; the first wide range single groove stationary control variable pitch sheave with both flanges moving simultaneously; simplified design that gives positive clamping of the two adjustable flanges eliminating fretting corrosion. Flanges are quickly and easily released for making speed changes; single wide belt gives maximum horsepower efficiency, and eliminates problem of maintaining matched belts and matched grooves for equal power distribution; less shaft overhang; adjustable at either end, single adjusting screw accessible at either end of the sheave; no lubrication, no grease fittings or oil cups.

T. B. Wood's Sons Co., Chambersburg, Pa.



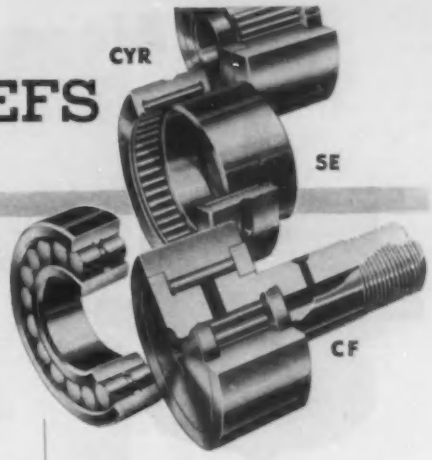
RESEMBLING CELLOPHANE in appearance, a new transparent film has found a variety of uses, such as: metallic textile yarn; electrical insulation; sound recording tape; liners for containers. The new film has a combination of mechanical strength, long-term resistance to heat, chemical inertness, and high dielectric strength, making it suitable for many industrial uses. E. I. Dupont & Co., Wilmington, Del.

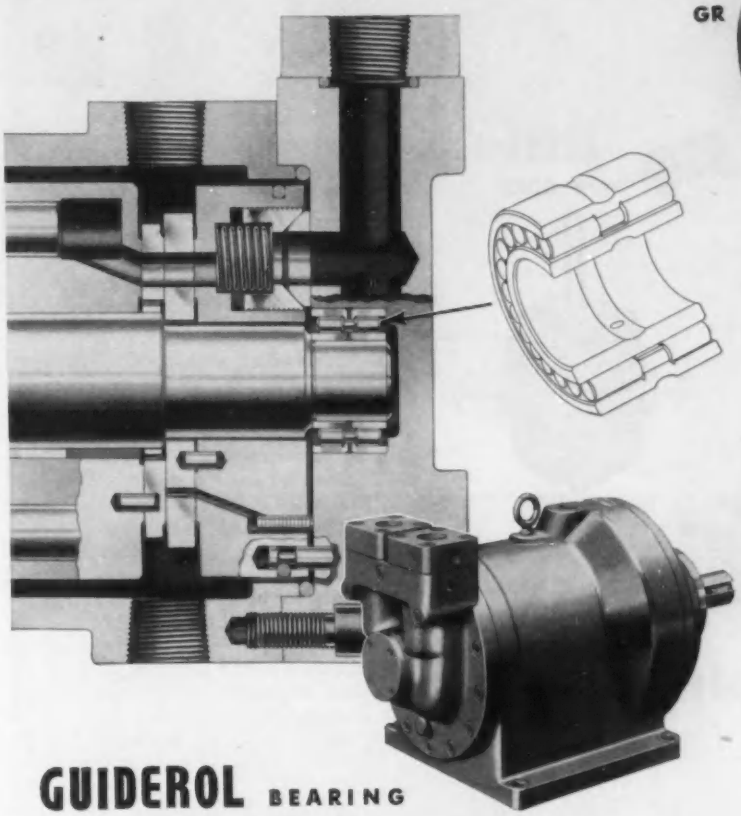
PUSH-BUTTON CONTROL, for window-type or air-conditioners, fans, and other appliances requiring multiple-circuit control, is possible with a new switch in 3, 4, 5, 6, 7 and 8-button styles for selection of two to six circuits and OFF, for operation at $1\frac{1}{2}$ hp, 115-230 v a-c. The push-buttons are obtainable in an unlimited variety of colors. Ark-Les Switch Corp., 51 Water St., Watertown 72, Mass.

SUPER-TOUGH SILICONE RUBBER with a tear strength of 190 psi have been used as O-rings and gaskets as seals for synthetic base oils at temperatures as high as 375 F. It is also used for molded ducts and connectors on hot air lines, particularly where oil mist is present. Having resistance to heat and cold, flexibility is maintained from —65 F to 550 F. General Electric Co., Plastics Div., Decatur, Ill.

CONTINUED ON PAGE 250

McGILL BEARING BRIEFS





GUIDEROL BEARING

used in pilot model Oilgear Motor

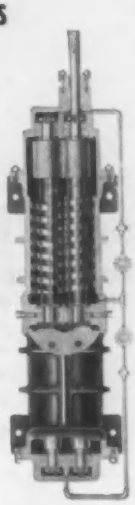
SHOWS NO WEAR AFTER 4000 HOUR TEST

The Oilgear Company, Milwaukee, Wisconsin, a regular McGill bearing user, has been testing a pilot model of a new 60 HP Axial Type Hydraulic Motor equipped with Guiderol Bearings for over a year. After 4000 hours of full load operation, the Guiderol Bearing used on the pilot end of the motor shaft was removed and inspected. It was still in perfect condition showing no internal wear.

This new line of lighter and faster operating axial piston units take advantage of the Guiderol bearing's assured freedom from skewing and extra load capacity in reduced radial bearing space.

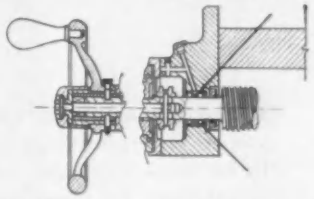
Mr. Ernst Wiedmann, Oilgear Chief Engineer, is enthusiastic about the performance of the Guiderol Bearings. He says: "They are the best full-type roller bearings for our hydraulic pumps and motors." As a result he is changing old specifications for this type of bearing to Guiderol and including Guiderol Bearings on all new developments.

WARREN-QUIMBY ADOPTS GR BEARINGS FOR MAXIMUM RADIAL LOADS



Warren Steam Pump Company has adopted Guiderol Bearings at five points of maximum radial load in this Warren - Quimby Vertical Screw Pump. The Guiderol Bearings have more load carrying capacity in the limited space available and enable vertical mounting of the pump without roller skewing or locking.

KEARNEY & TRECKER FINDS LIFE FACTOR INCREASED IN TABLE FEED APPLICATION



The life factor of the shaft bearing on the table feed screw of Kearney & Trecker Milling Machines has been increased by the simple process of changing to Guiderol Bearings. These bearings increased capacity, performance and bearing life.

BEARING SELECTION GUIDE
A new 140-page Bearing Selection Guide, complete with 30 pages of vital engineering data, has been released by the McGill Manufacturing Co. Ask for Catalog No. 52.

McGILL® — Precision Bearings
McGILL MANUFACTURING COMPANY, INC.
201 N. Lafayette Street, Valparaiso, Indiana

Air or hydraulic...

big...
24″ BORE

little...
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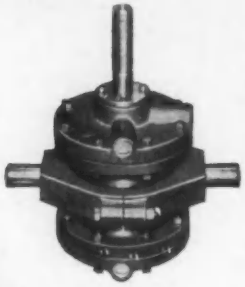
standard...



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COMPOUND CYLINDER
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• When you bring your power cylinder problems to Anker-Holth, you get the engineering assistance of cylinder specialists . . . backed by our modern manufacturing facilities. There is no compromise. If it takes a special cylinder—regardless of size or type—you get the *right* power cylinder for your specific requirements . . . air or hydraulic.

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FREE on request... bulletin on complete line of Anker-Holth products.

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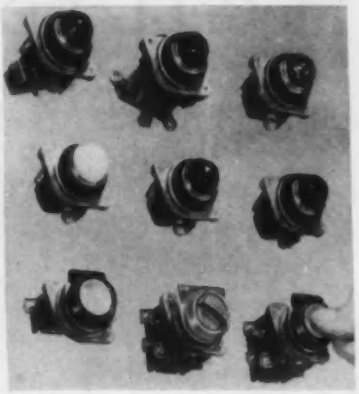


Heavy-Duty Oiltight Indicating Lights

Heavy-duty oiltight indicating lights for a line of oiltight pushbuttons, selector switches, and accessory controls have all-glass faceted lenses that are factory sealed to metal caps, and feature all-angle visibility. They are available in six colors: red, green, white, blue, amber and clear.

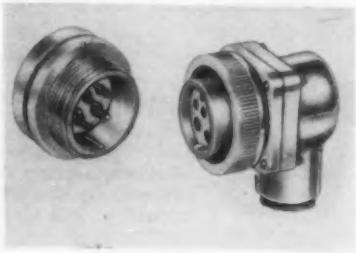
To provide more versatility and easier installation, the lights are designed for both front and back mounting.

Available in three forms, resistor, transformer and full-voltage, they are rated from 110 to 600 v with a 10 amp continuous rating.

General Electric Co., Schenectady 5, N. Y.

Miniature Right Angle Electronic Connector

The CRA5-2 is a new design giving a miniature, pressure-tight electronic connector in a die cast aluminum shell. Suitable for use in air-borne and portable equipment, particularly applications requiring mechanical protection with pressurization, sealing is accomplished throughout the connector and around each contact by the use of individual O-rings. Individual rings assure positive sealing and allow the contacts to float, thereby preventing alignment difficulties. Air leakage is



here are the

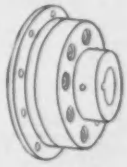
AJAX

answers to your direct drive problems

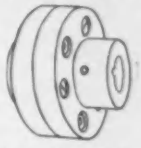
Ajax Flexible Couplings are made in a wide range of sizes and capacities to handle alignment problems on direct-driven machines. Hundreds of thousands in use. Performance proven over 30 years. Write for catalog.

Ajax Type A Semi-Steel and Type S Forged Steel Couplings

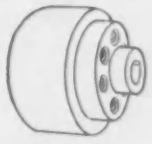
Ajax Type SP Shear Pin Coupling



Ajax Type BO Bolt-On Coupling

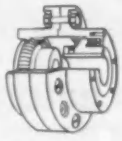


Ajax Type M Mill Motor Coupling



Ajax Type BD Brake Drum Coupling

Ajax No. 423-523 Couplings for full motor speeds



Ajax Dihedral Coupling

AJAX FLEXIBLE COUPLING CO. INC.

WESTFIELD, N. Y.

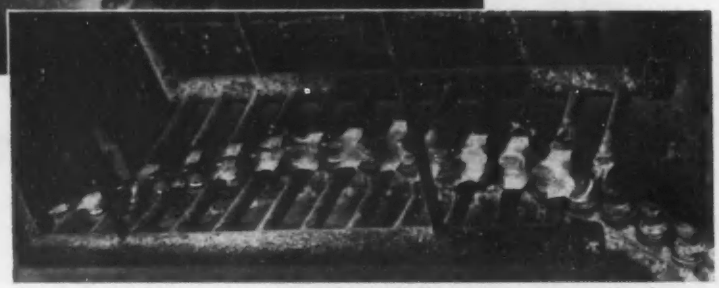
It's easy to get any brazing output you want with EASY-FLO SILVER BRAZING ALLOYS

Here's the formula:

1. Prepare the assemblies for brazing with the alloy preplaced in a form suited to the joints.
2. Use a fast heating method such as oxy-acetylene torch, gas-air burners, electrical induction, furnace, etc.
3. Plan a set-up that will keep assemblies moving steadily to and through the heating station.

Here's an example from a company specializing in metal joining – Salkover Metal Processing of New York, Inc., Long Island City, N.Y.

Above are the parts—a brass valve and the cap of a fire extinguisher body, with the 9/16" square of .005" EASY-FLO 35 used to join them. At left is the turntable and gas-air burner set-up, with close-up of burner station below.



Operator at right puts caps on turntable and alloy squares on caps. He also flips finished assemblies into water barrel. Operator at left applies Handy Flux and sets valves on top of alloy. Output—720 per hour—or one every 5 seconds—and every one strong and permanently leak-tight.

Are you taking advantage of fast EASY-FLO brazing production methods like this in making parts for your refrigerating equipment?

GET BULLETIN 20 FOR FULL DETAILS

It covers correct joint design, alloy forms for preplacement and fast heating and production methods. Also tells why you are assured of strong, leak-tight joints when you braze with EASY-FLO low-temperature silver brazing alloys.

HANDY & HARMAN

General Offices: 82 Fulton St., New York 38, N. Y.

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less than 1 cu in. per hr at a pressure differential of 30 psi.

Some features include: easy removal of plug cap for soldering of cable wires to contacts; right angle cable entry; coupling lock ring for quick engagement and disengagement; and positive polarization of mating parts.

Mineral-filled melamine insulator bodies for high dielectric and mechanical strength house five No. 20 AWG contacts (5 amps) and two No. 18 AWG contacts (7 amps). Contacts are gold plated over silver for low contact resistance, prevention of corrosion and ease of soldering.

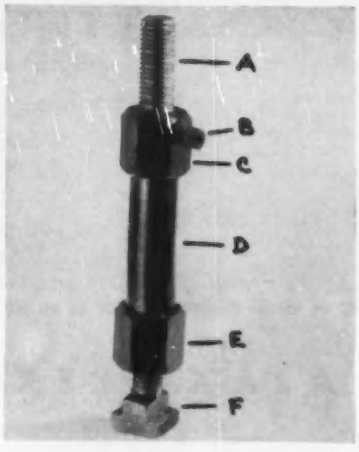
The voltage breakdown between closest contacts at sea level, 3,750 v d-c; at 60,000 ft altitude, 1,100 v d-c. Weight of panel mounted receptacle, 0.6 oz; weight of cable mounted plus,

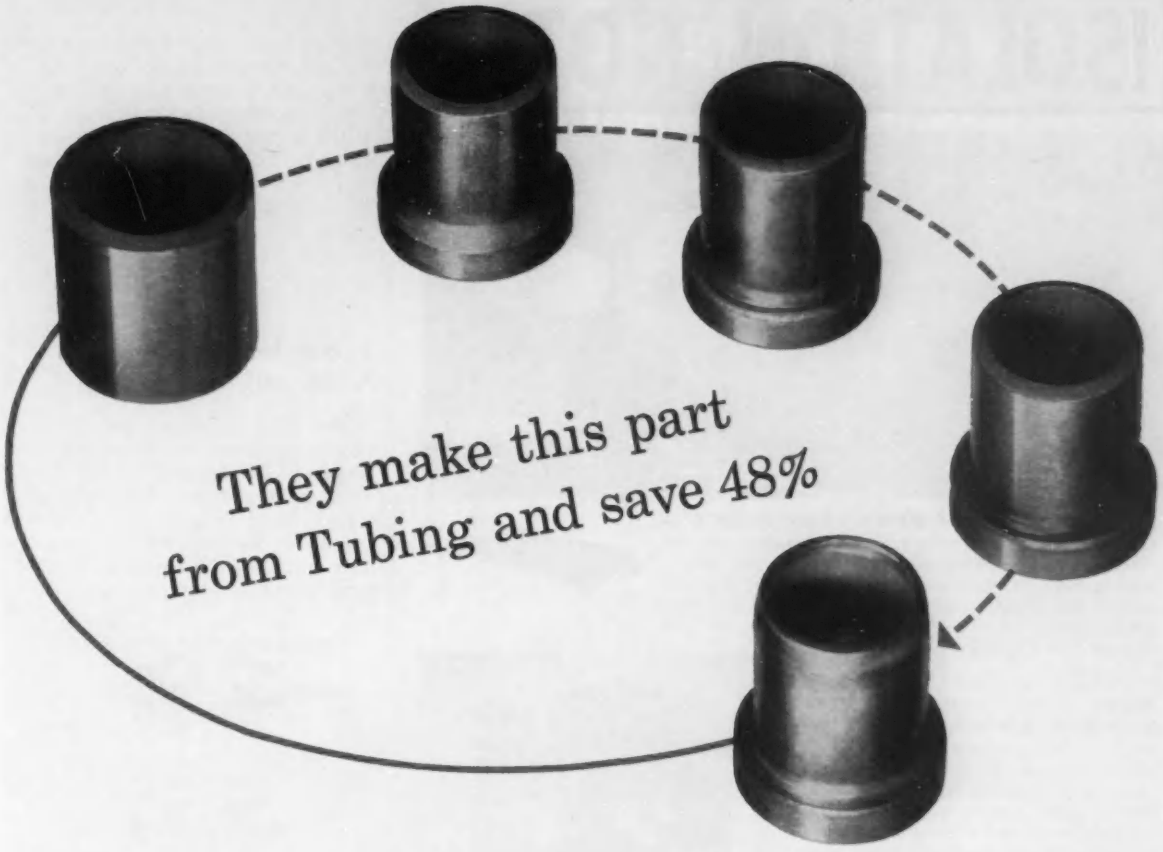
Winchester Electronics, Inc., Glenbrook, Conn.

Bolt Easily Adjusted In Length

The Q-bolt, a new T-slot type bolt which can be easily adjusted in length, consists of a steel tube (d) with hex ends, each end with threaded ID. One end (E) receives a T-solt bolt (F), (or, for example, standard hex-head bolts, eye-bolts, carriage bolts or machine bolts); the other end (C) receives a threaded stud (A) which has two parallel flat sides. The ID of this hex and (C) has two matching grooves milled through the threads.

In this manner, a quarter turn of the threaded stud in either direction engages or disengages the thread from the body of the bolt, permitting the stud, when disengaged, to move freely up and down in the tube. This allows the overall length of the Q-bolt to be quickly adjusted to the position re-





This part used to be made out of solid bar stock on a screw machine. Costly? You bet. 12½ cents each. Lots of expensive machining. Lots of metal wasted to make a hole.

Now, Northwestern Corporation, Morris, Ill., makes it out of tubing. ELECTRUNITE Mechanical Tubing, 1½ O.D. x 11 gage. The customer gets it in 14-foot lengths, cuts it off into 2" lengths.

Next, the tubes are formed in a series of dies. Pretty drastic reductions, but the ELECTRUNITE Tubing can take it. Then they're machine finished in one operation.

The result: Each part now costs only 6½ cents. Multiply that by several million parts a year the manufacturer produces and you come up with a sizable saving.

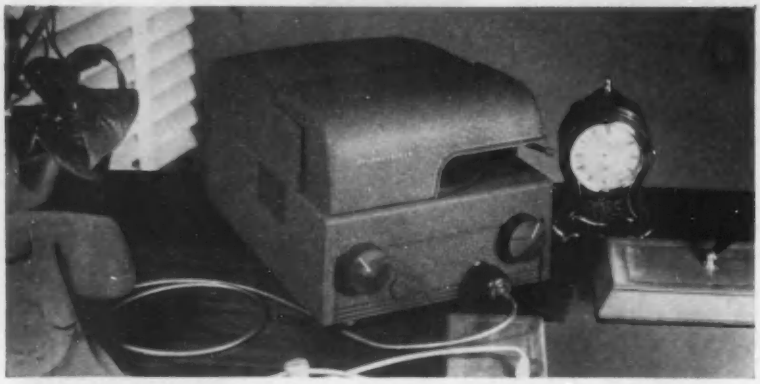
Unusual, you say? Not at all. Republic has helped a lot of manufacturers cut costs drastically by helping them design with Republic ELECTRUNITE Tubing. A call to your nearest Republic Sales office will bring you all the facts.

REPUBLIC STEEL CORPORATION
Steel and Tubes Division
222 E. 131st Street, Cleveland 8, Ohio
GENERAL OFFICES • CLEVELAND 1, OHIO
Export Department: Chrysler Building, New York 17, N. Y.

Republic
REPUBLIC STEEL
ELECTRUNITE TUBING

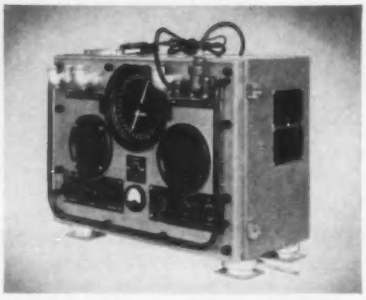
SHOCK – VIBRATION – NOISE

ISOLATION NOTES



DICTATING MACHINE FLOATS ON BARRYMOUNTS — For noiseless operation, smooth, faultless playback, and the ultimate in protection against vibration and shock, Soundscriber Corp. chooses Barrymounts to support their new transcription unit. One more instance of how Barrymounts protect the performance of precision instruments. *Ask for data on Type 372 Barrymounts.*

COAST GUARD DIRECTION FINDER GUARDED BY BARRYMOUNTS — Where reliability of performance is really vital, sensitive electronic equipment *must* be protected from shock and vibration. Raytheon Manufacturing Company says: "We find that the high quality and effectiveness of these mountings help us assure the famed reliability and excellence of our own products." *Ask for data on Type C-2000 Barrymounts.*



ALL-METL BARRYMOUNTS PROTECT AIRCRAFT RADIO COMPASS — For safe, assured, brilliant operation, at extremely high altitudes and over a wide range of temperatures, Lear uses Barry ALL-METL vibration isolators to support the sensitive components of their "Executive" radio compass. They say: "We have chosen the Barry product because we feel it is a superior product from the standpoint of providing greater trouble-free life". *Ask for data on Type M-44 Barrymounts.*

INDUSTRIAL MACHINERY MOBILIZED BY BARRYMOUNTS — For example: a production line of eight punch presses was shut down, moved 200 feet across the plant, and was producing parts again *in a total elapsed time of 23 minutes.* No lagging, no shimming, and no walking of the machines in operation — because they were mounted on the new Leveling Barrymounts. This is *machine-tool mobility* — a new idea to make new profits for YOU. *Ask for "LOOK — NO LAGGING!"*

The wide range of Barry products and the experience of Barry engineers can help you solve shock, vibration, and noise problems in any area of military or industrial activity. Call our nearby sales representative or write directly to us.

THE **BARRY** CORP.

730 PLEASANT ST., WATERTOWN 72, MASSACHUSETTS

SALES REPRESENTATIVES IN

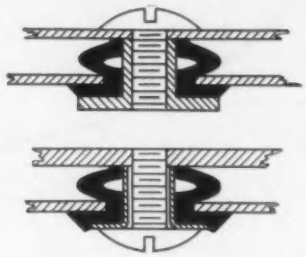
Atlanta Baltimore Chicago Cleveland Dallas Dayton Detroit Kansas City
Los Angeles Minneapolis New York Philadelphia Phoenix Rochester
St. Louis San Francisco Seattle Washington, D.C. Montreal Toronto

quired. Once engaged, the stud is held securely in position by the thumbscrew (B), which can be only finger-tight. No matter what stress is subjected to the stud, the thumb-screw can again be loosened with the fingers. Four Q-bolts in the different sizes will extend over any length from 8 to 42 inches.

Techno Products, Inc., 1908 *E. 66th St., Cleveland* 3, *Ohio*

T-Nut Isolator of Noise and Vibration

Ease of installation, and effective isolation of noise and high-frequency vibration, are features of the new T-nut isolators shown. These units are typically used to quiet small motors, to isolate sensitive assemblies in aircraft and guided missiles, to protect panel-mounted instruments, and to reduce transformer hum. With a natural frequency of 35 to 40 cps, they provide isolation of disturbing vibrations at 100 cps and above.



The method of use, including blind wall installation, is indicated. The T-nuts will fit through plates up to $\frac{3}{16}$ in. thick, in four available core lengths. Only $\frac{1}{16}$ in. to $\frac{1}{8}$ in. clearance is needed between the isolated assembly or unit and the mounting panel. The core is either clearance-drilled or tapped for any of several common machine-screw threads. The resilient material is either rubber, GRS or neoprene.

The Barry Corp., 830 *Pleasant St., Watertown* 72, *Mass.*

Positive Shut-Off Midget Solenoid Valves

This new series of midget magnetic shop valves has been designed for use with all types of gases and fluids. The valves operate in any position and feature positive shut off, low current consumption, optional time-delay, and adjustable by-pass and main flow.

One of the miniature valves, the K-27, is said to be especially suited

It's Here! Non-Corrosive Soldering Of Any Type Aluminum Alloy

WIRE S-X PRODUCTS

Aluma-Flux

SOLDERING FLUX

. . . A UNIVERSAL FLUX FOR ALL COMMERCIAL METALS USUALLY JOINED BY SOLDERING

The success of S-X Aluma-Flux in the soldering of aluminum is due to the action in which the flux initially reduces surface oxides and then immediately deposits a thin layer of plating material on the solder area. Oxidation of the area to be soldered is thus prevented while the plating material serves as an approved base on which to solder. In addition to its soldering efficiency, Aluma-Flux reacts completely during the joining operation so there are no corrosive flux residues to lower corrosion resistance of the finished joint.

Manufactured By
ESSEX WIRE CORPORATION
Ft. Wayne, Ind.

HERE is the only flux ever made that assures the *non-corrosive joining* of every type of aluminum alloy regardless of soldering method—mechanical, manual or dip. No corrosive residue remains in most cases, and soldered pieces can be used immediately after the joining operation.

In addition to aluminum, use S-X Aluma-Flux for soldering stainless steel, nickel, brass, copper, bare or galvanized steel, cast iron, and other ferrous alloys. Use it for the quick and easy joining of unlike metals such as brass and aluminum, and for coating copper with tin. There is no other flux like it!

Even when exposed to salt spray, high humidity, alkaline water and other normal corrosion-inducing conditions, aluminum joints made with S-X Aluma-Flux produce no corrosive action. No type of detrimental effect on any soldered joint results from Aluma-Flux.

S-X Aluma-Flux is equally effective when used in molten form, or in powdered form as delivered, whichever is best for the job. Practically any type of solder can be used. And because Aluma-Flux is non-hygroscopic—will not absorb water—it can be stored indefinitely without change of weight or fluxing efficiency.

Write For Test Sample & Details

Aluma-Flux Is Ready For Immediate Shipment In Convenient Size Metal Containers

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INSULATION and WIRES incorporated
1534E Swinney Ave. • Ft. Wayne 6, Indiana

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With broad experience in compounding natural rubber and all synthetic polymers, ACUSHNET specializes in custom-engineered "precision" molded rubber parts made exact to specifications. None are stocked.

If molded rubber parts are to perform a service vital to the efficiency, longevity and reputation of your products, discuss your requirements direct with our engineers. Their collective, specialized knowledge of mold design, modern compounding techniques and production efficiencies can be applied to your problems with effective, economical results. Especially valuable is this knowledge when applied in the initial stages of your design.

Send for your copy of the widely used "Acushnet Rubber Handbook", a comprehensive, practical rubber data reference. Please make request on your company letterhead.

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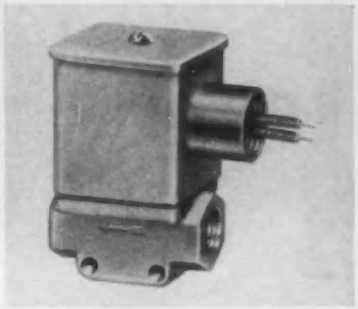
PROCESS COMPANY

Address all communications to 768 Belleville Ave., New Bedford, Mass.



for such an application as that found in a vending machine. Its dependability, pressure range and variety of body materials (aluminum, brass and stainless steel) are factors, plus the ability to stand up under continuous cycling and to give rapid, positive shut off.

Another type, the K-28, is designed specifically for use in domestic oil burners. A built-in, time-delay action prevents immediate opening of the valve until the oil burner motor gains full running speed.

The last valve in this midget series is the K-29, for use in both domestic and commercial oil burner installations. It is of the manual reset type and dependable safety is featured in the valve. The K-29 fails safe on current failure or unsatisfactory voltage conditions, and must be manually reset after the trouble is corrected.

General Controls Co., 801 *Allen Ave., Glendale, Calif.*

Small Pressure Gage Withstands Heavy Shock

Available in a variety of dial sizes, cases and capacity ranges, new pressure gages may be obtained with a dial diameter as small as one inch and a total weight of less than two ounces. Applications to date include airplanes, missiles, branches of the oil and chemical industries.

The gages will withstand shock tests

Specify

GITS *Unit* SEAL

Result:

Economy

"Economy... counts not in savings but in selection."—*Edmund Burke*

Economy through Efficiency

Gits Unit Seal proves itself in dependable performance over a wide range of operating conditions—including extra-high speed, heat and pressure applications. Operation at peak efficiency always means dollars-and-cents savings.

Economy through Adaptability and Versatility

Gits Unit Seal fits many applications as a standardized item actually carried in stock. You harness the savings of mass production to your own specific needs. Gits Unit Seal already has wide application in the following fields: Washing Machines, Disposal Units, Gear Motors, Speed Reducers, Aircraft Turbine Pumps, Accessory Drive Units, Jet Propulsion Units, Electrical Power Equipment, Automotive Accessories, Business Machines, Standard and Special Machine Tools.

Economy through Long Life

Gits Unit Seal is designed for maximum life in any recommended application. Here's the real "proof of the pudding" in saving money.

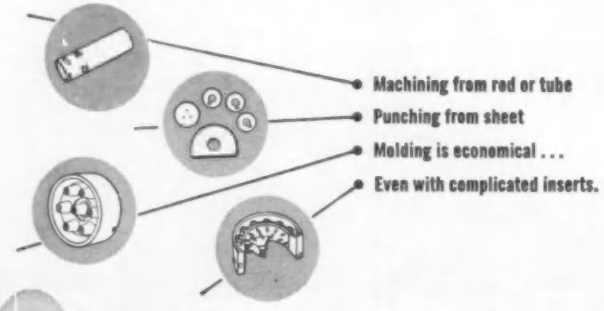
Write Today For FREE Illustrated Brochure, or send us your seal problem. Our experienced engineering staff is at your service.

*Cartridge Seal . . . requiring only 25% more space than lip-type seals.

GITS BROS. MFG. CO.

1838 S. Kilbourn Avenue Chicago 23, Illinois

Looks complicated, but this connector strip was actually produced by a few simple machining operations on standard Ace hard rubber rod. The design engineers chose an Ace compound that not only has excellent strength (up to 10,000 psi), excellent surface resistance and top insulating properties, but also is free-machining. A few high-speed milling and drilling operations, then soften by heating, press in the metal inserts, assemble the contacts with screws, and the job's done. An amazing variety of shapes and compounds of Ace Hard Rubber are possible, even extruded directly over metal rods or tubes. Stir your imagination? Write for more facts today.



ACE rubber and plastic products

AMERICAN HARD RUBBER COMPANY
93 WORTH STREET • NEW YORK 13, N. Y.

to 50 G, and vibration tests at 8 G's of 20 to 500 cycles per sec have been made.

Pressure ranges run from 0 to 100 and 0 to 60,000 graduation readings. Other features are: hermetic sealing, fungus and corrosion resistance. Upkeep is low as there are no gears, segments, hair springs, linkages, shafts or bearings.

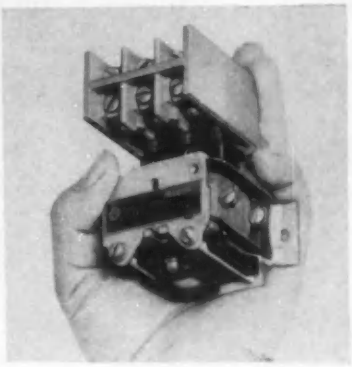
They may be panel or line mounted and have standard NF or NG threaded connections, with side or rear outlet as desired.

Their construction provides a self-dampening action, and the gage will withstand a 100 percent graduation range overload.

Designers for Industry,
4746 W. Washington Blvd.,
Los Angeles 16, Calif.

Small, Powerful Magnetic Contactor

Rated up to 5 hp at 208-550 v, and furnished in 2, 3 or 4 poles, these new little giant magnetic contactors feature small size, lightweight, easy access to coils and contacts, plus simplicity of construction. Wide contact



gap, $\frac{21}{64}$ in. has advantages in reversing contactors to avoid flashover during rapid reverses.

Used in air conditioning and heating units, hoists, door openers, packaging and baling machines, mobile cranes and ovens, these contactors are adaptable to applications requiring a compact magnetic switch for intermittent or continuous duty.

Furnas Electric Co.,
1050 McKee St., Batavia, Ill.

Longe Range Pulse Timer

A new long range pulse timer has recently been developed with a unique arrangement of cams rotating at dif-

If Your Fastening Problem Involves—

- VIBRATION
- FATIGUE
- IMPACT
- SHOCK

Lamson PLACE BOLTS will solve it

The Lamson Place Bolt answers many fastener problems where vibration is a factor.

Special slots in the head of the bolt plus a circular recess around the under side of the head combine to provide spring or locking action of the head against the tapped material. As the bolt is tightened the segments of the head are forced inward, this flexibility adds to the elasticity of the shank and the locking efficiency of the bolt.

The slotted Place Bolt can carry as much load as a conventional bolt because the shear section of the head is stronger than the tensile stress area of the thread.

HOW PLACE BOLTS MAINTAIN TENSION

It is well known that bridges are constructed to "give" when encountered by high-velocity winds and that the strongest buildings are not rigid in construction, even successful boxers learn to roll with the punch. This same principle governs the design of the Place Bolt.

The flexible area between the slotted segments in the upper face of the bolt head and the recess adjacent to the shank in the lower face acts as a controlled spring element. The amount of "spring" is in proportion to the wrenching torque applied.

Tension is maintained because the elastic flexing of the head, added to the overall elastic elongation of the shank, permits greater loss in clamping distance before tension drops to zero. At the same time, ability to resist shock is greatly enhanced by the added elasticity.

For the whole story, send for the Lamson Place Bolt folder.

Lamson & Sessions

The LAMSON & SESSIONS Co.
1971 West 85th St. • Cleveland 2, Ohio
Plants at Cleveland and Kent, Ohio • Birmingham • Chicago

FOR PROMPT DELIVERY AND HELPFUL SERVICE, ORDER FROM YOUR LAMSON DISTRIBUTOR

PLUG NUTS — Ideal for blind or hard-to-reach places.

PIPE PLUGS — Forged steel, heat-treated.

"1035" SET SCREWS — Cup point type, hardened and heat-treated.

PLACE BOLTS — With "Built-in" spring action for positive locking.

LOCK NUTS — Economical, vibration proof. Can be used repeatedly.

"BENT BOLTS" — Including U bolts, eye bolts, hook bolts, etc.

MACHINE SCREWS — Clutch and Phillips recessed head screws.

SEMS — Pre-assembled lockwashers on tapping and machine screws.

It's New! It's Different! It's Better!

New Formula Copyflex Paper Makes Outstandingly Better Prints

Want to see how really sharp and contrasty a print can be? Then try the new Copyflex sensitized paper—the paper that sets a new high in quality of reproduction.

It's based on a new formula developed by Bruning's research staff and, of course, exclusive with Copyflex. Images reproduced on this superb paper are measurably sharper and blacker, with a uniform density that makes for the sharp contrast you've always wanted but never before achieved. No "washed out" areas—no mottled gray flecks.

The new formula paper "perks up" weak image lines from poor originals—even captures various shades of gray in pencil sketches. Yet, notwithstanding its superior fidelity of reproduction, it provides a wider margin for operator error. Anyone can make good prints on this fine paper!

Every day you delay, you're paying for Copyflex quality but not getting it—so order today. New formula Copyflex paper comes in three speeds, in both sheet and roll form, up to a maximum width of 54 inches.

MUCH MORE CONTRAST!

MUCH TRUER REPRODUCTION!

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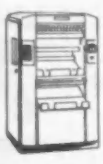

BRUNING Copyflex

Copies anything typed, written, printed or drawn on ordinary translucent paper—in seconds

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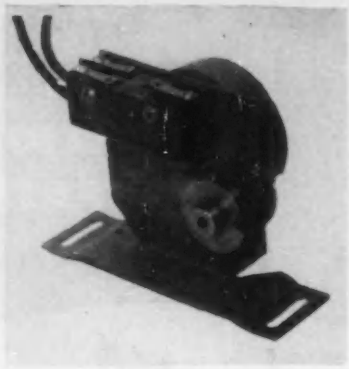
Everything for the Engineer and Draftsman



ferent speeds, which provides accurate momentary pulses even when spaced considerably apart in respect to time. Such pulses will occur regularly at factory pre-set intervals. The frequency of pulses is altered by changing gears and may be set from 1 pulse every 15 sec to 1 pulse per week.

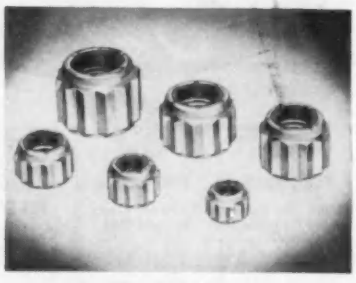
The time between pulses is said to be up to 30 times greater on this unit than on a conventional timer having cams anchored directly to motor shaft without loss of rapidity of "make" and "break" contact action, decreasing of pulse, or decrease in accuracy of pulse.

Hagen Mfg. Co., Inc.,
202 *Twentieth St., Moline, Ill.*

High-Strength Titanium Locknuts

Improving aircraft speed, range and performance through reduction of fastener weight has been accomplished with a new line of titanium locknuts. According to the manufacturer, these new locknuts are said to be the first commercially-available.

Made of high-strength titanium alloy, these stop nuts will meet AN tensile strength requirements for steel nuts of the same thread size, but will weigh less than half as much as steel hex nuts. First production will be of 12-point (double hex) nuts with nylon locking collards, in sizes $\frac{5}{16}$ to $\frac{5}{8}$ inch. Other types will be added later. Special permanent coating developed



PATENTED

Welded Terminals

Proved by Years of Service

NOW AVAILABLE IN ALL

OHMITE®

WIRE-WOUND RESISTORS

Provide a Perfect, Permanent Connection between Resistance Wire and Terminal

WELDED RESISTANCE WIRE

All Ohmite resistors now have the resistance wire welded to the terminals instead of soldered or brazed. This provides a resistor with superior characteristics.

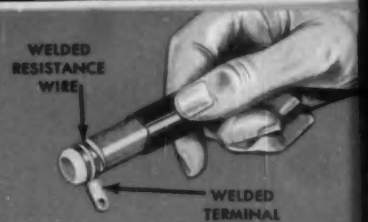
WELDED TERMINAL LUG

Another Ohmite resistor feature is the welded terminal band. The band is permanently held together around the resistor tube by means of welding, providing a strong, permanent fastening.

SEE NEXT PAGE ➡

Now in All Sizes . . .

Welded Terminals



ON OHMITE® RESISTORS

PATENTED OHMITE PROCESS ASSURES **PERFECT WELDS**

Ohmite has perfected and patented a new welding technique, and has developed a method of testing every weld between the resistance wire and terminal. Thus, with every Ohmite resistor, you are assured of permanent terminal connections, unaffected by vibration or high temperatures.

PERFECT ELECTRICAL CONNECTIONS

The fusion of the metal in the resistance wire and terminal lug provides a perfect and permanently stable electrical connection. This is extremely important in eliminating noise in audio circuits or instability in other highly sensitive circuits.

HIGH-STRENGTH ALLOY TERMINALS

The terminals on Ohmite resistors are made of a special high-strength alloy, which has a coefficient of expansion that is properly related to that of the enamel, ceramic core, and wire. This keeps the terminal firmly anchored, and prevents cracking of the enamel.

The resistance wire is welded practically flush with the terminal, so there is no projection extending from the surface. Hence, the connection and terminal are as well covered and protected by the vitreous-enamel coating as the winding itself.

PROVED IN TEN YEARS OF SERVICE

Ohmite developed welded terminals more than ten years ago. Since that time, this construction has been gradually extended to cover the entire Ohmite line. Millions of these welded resistors have proved their reliability in the toughest kind of service.

WRITE on Company Letterhead for Catalog and Engineering Manual No. 40.

Be Right with

Plus THESE OTHER OHMITE FEATURES

Ohmite resistors provide other important advantages, too—a superior vitreous-enamel covering, which holds the winding rigidly in place, preventing "hot spots," and protecting the winding from moisture and fumes; strong ceramic core that is unaffected by cold, heat, fumes, or high humidity; and hot tinned terminal lugs for ease in soldering. For unfailing dependability, specify Ohmite resistors.

OHMITE MANUFACTURING CO.
3611 Howard Street, Skokie, Illinois (Suburb of Chicago)

OHMITE®

RHEOSTATS • RESISTORS • TAP SWITCHES

for these nuts will reduce seizing and galling to a minimum.

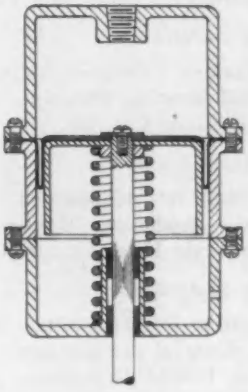
An airplane manufacturer has estimated that substitution of titanium for steel in aircraft fasteners could save as much as 213 pounds on a fighter plane. Titanium is heavier than aluminum, but is also a greal deal stronger and retains its usable strength up to 800 F.

Elastic Stop Nut Corp. of America, 2330 Vauxball Rd., Union, N. J.

New Seal Has Combination Bellows And Diaphragm

Bellofram is the result of combining the words bellows and diaphragm, and means, as it shows in the illustration, a new type of piston seal. It is a long stroke, deep convolution, constant area diaphragm with increased flexing life and low spring gradient. Freeze-up, friction losses and leakage are not problems.

They are frictionless, free positioning and completely relaxed at all points within their stroke. Applica-



tions fall into three separate classifications: (1) Instruments—for repeatedly converting pressure (gas or liquid) into a corresponding force or displacement with precise accuracy; (2) power actuators and motors—for converting pressure into a long stroke at high thrust levels without mechanical friction; (3) seals—to prevent leakage of gas or liquid across a moving piston or shaft without introducing mechanical friction or spring gradient.

The seals have good cycle life. They can be made to operate at pressures ranging from $\frac{1}{4}$ in., H_2O min to 500 psi and over a wide temperature range. The change in effective area is controlled by the surrounding accuracy of the mating parts.

The Bellofram Corp., 144 Moody St., Waltham, Mass.

where frequent opening and closing are required . . . specify

CAMLOC® FASTENERS

TIGHTER

QUICKER

MORE ECONOMICAL

On panels, doors or covers, Camloc Fasteners provide security against opening due to vibration. Originally developed for use in aircraft, Camloc Fasteners have since been adopted by other industries because the basic design offers many advantages. Camloc opens or closes with a quarter turn of the stud, yet the combination of cam, spring and detent provides a uniform locking torque that grips firmly, positively and durably. Camloc Fasteners are easily installed because the cross pin is an integral part of the stud and the stud is quickly inserted with pliers After installation, when the panel is removed or opened, the stud remains attached to the outer panel so that no part can possibly be lost. Our engineers can help you make the most effective use of Camloc Fasteners, by suggesting the most efficient assembly methods and by determining the minimum number of fasteners required to perform a given job. Your inquiry will receive our prompt attention.

Write for our illustrated brochure containing descriptive information on the basic Camloc fastener line. Address your request to 62 Spring Valley Road, Paramus, N. J.

VIBRATION-PROOF

In years of constant use in aircraft—where vibration is always a bugaboo—CAMLOC Fasteners have proven themselves again and again

POSITIVE LOCKING

Spring loading plus cam action, with a cross pin that can't come out, guarantee CAMLOC Fasteners against accidental opening

OPEN & CLOSE QUICKLY

A quarter-turn with a screw driver—or of the wing head—opens or closes the CAMLOC Fastener. important where quick access is vital.

SAVE MONEY 3 WAYS

CAMLOC Fasteners cost less to install. eliminate costly replacement because they're made to take frequent use . . fewer do the job.

CAMLOC® FASTENER CORPORATION

MAIN OFFICE AND FACTORY
PARAMUS, N. J.

WEST COAST OFFICE
5410 WILSHIRE BOULEVARD
LOS ANGELES 36, CALIF.

O & S SELF-LUBRICATING BEARINGS

OS BEAR ANNOUNCES . . .

O & S BEARING & MFG. CO.
FABRYLON
BEARINGS & BUSHINGS

. . . THE TRADENAME OF A PROVEN PRODUCT

DEPENDABLE
RUGGED
SELF-LUBRICATING

FABRYLON Combines . . .
The famous O & S lubricant impregnated fabric with rugged molded nylon . . . a proven, dependable bearing you can install and forget.

FOR CORNER LOADING AND HIGH SHOCK LOADS

WRITE FOR BULLETIN #153

O & S BEARING & MFG. CO. FABRYLON BEARINGS & BUSHINGS

NeverOil • SINCE 1918 •

O&S BEARING & MFG. CO.
777 W. EIGHT MILE ROAD • WHITMORE LAKE, MICHIGAN

MEETINGS

March 10-12

AMERICAN SOCIETY OF MECHANICAL ENGINEERS—International Meeting, Hotel Del Prado, Mexico City.

March 15-19

NATIONAL ASSOCIATION OF CORROSION ENGINEERS—Conference and Exhibition, Municipal Auditorium, Kansas City, Mo.

March 16-17

STEEL FOUNDERS' SOCIETY OF AMERICA — Annual Meeting, Edgewater Beach Hotel, Chicago, Ill.

March 17-19

PRESSED METAL INSTITUTE—Spring Technical Meeting, Hotel Carter, Cleveland, Ohio.

March 22-25

INSTITUTE OF RADIO ENGINEERS—National Convention and Exhibit, Waldorf-Astoria Hotel, New York.

March 24-April 1

AMERICAN CHEMICAL SOCIETY — National Meeting, Municipal Auditorium, Kansas City, Mo.

March 29-31

SOCIETY OF AUTOMOTIVE ENGINEERS — Production Meeting and Forum, Drake Hotel, Chicago, Ill.

March 30-April 8

UTRECHT INTERNATIONAL TRADE FAIR—Electrical and Engineering Exhibition, Utrecht, Netherlands.

April 3-4

PACKAGING MACHINERY MANUFACTURERS INSTITUTE—Spring Meeting, Hotel Dennis, Atlantic City, N. J.

April 5-6

SOCIETY OF THE PLASTICS INDUSTRY—Annual Conference, Mount Royal Hotel, Montreal, Canada.

April 5-8

AMERICAN MANAGEMENT ASSOCIATION — National Packaging Exposition, Convention Hall, Atlantic City.

April 12-15

SOCIETY OF AUTOMOTIVE ENGINEERS—National Aeronautic Meeting, Hotel Statler, New York, New York.

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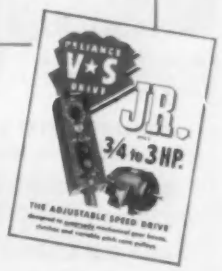
Ask for Bulletin D-2102. It describes and illustrates features, applications, components and operation; dimensions and characteristics also are included.



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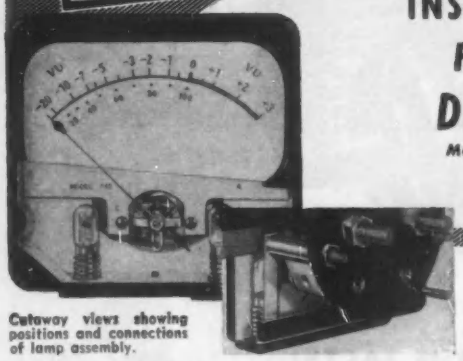

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Catalogs and Bulletins

Request additional information using postcards following page 228

(1) HYDRAULIC PUMPS AND MOTORS—N. Y. Air Brake Co., Bulletin 139, 4 pp. Points out features and gives selection data for the complete line of oil hydraulic pumps and motors. Large cutaway view shows features of the unit. Also has selection charts for pumps and motors, plus a recommended drive speed.

(2) SPECIALIZED INSTRUMENTS—F. W. Dwyer Mfg. Co., Bulletin, 4 pp. Illustrates and describes a broad line of specialized instruments and gages; including those for accurate measurement: combustion; draft; pressure; flow; vacuum; CO_2; smoke; velocity; static pressure; pressure differential; temperature; and similar studies.

(3) SILICONE FINISHES — Dow Corning Corp., Data Sheet 7-100, 5 pp. Explains the difference, in terms of performance, between the 100 percent silicone, the silicone-alkyd, and the modified silicone finishes. Examples are given and general recommended application methods are discussed. The use and performance of silicone fluid additives for organic-based finishes are also mentioned.

(4) ELECTRIC HEATERS—General Electric, Booklet GEC-1005 E, 60 pp. Units are described in terms of application, special features and installation. Many photographs and drawings illustrate immersion, strip, cartridge, tubular, insertion and fin heaters, thermostats, switches and oven heaters. Also has methods for determining power requirements and heat losses for many applications.

(5) MEASURING FLATNESS — Crane Packing Co., Bulletin L-404,

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PHOSPHATE COATINGS TO MAKE YOUR PRODUCT DURABLE*

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For more than a third of a century, ACP research chemists and ACP technical representatives in the field have pioneered in the science of metal preservation. They have developed surface treating chemicals which either protect metals directly, or create a superior bond for decorative and protective paint finishes, and now, ACP chemicals and processes are being used the world around to reduce costs, speed production and add to the life-span of countless products.

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"GRANODINE"® zinc phosphate coatings improve paint adhesion on automobiles, refrigerators, projectiles, rockets, and many other steel and iron fabricated units or components.

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Catalogs and Bulletins.....continued

6 pp. Tells how to read light bands in the interpretation of surface flatness. Illustrations show how various samples, circular and rectangular, appear under the optical flat when using a monochromatic light source.

(6) ELECTRICAL ACCESSORIES—General Radio Co., Catalog N, 258 pp. A complete listing of all products made, along with a photo, description, capacity, curves, and wiring diagrams. Among the accessories listed are: industrial instruments; motor speed controls; resistors; capacitors; inductors; impedance bridges; amplifiers; null detectors; coaxial elements; standard-signal generators; oscillators; meters; frequency measuring equipment, and others.

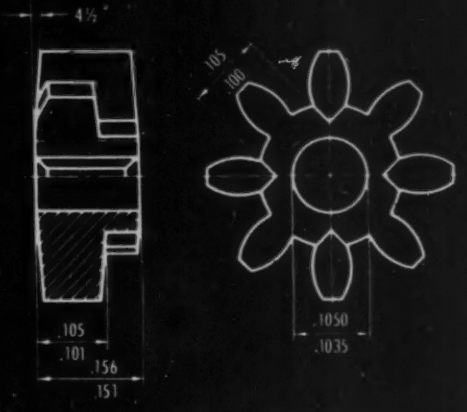
(7) HYDRAULIC COMPONENTS—Blackhawk Mfg. Co., Bulletin 3B, 4 pp. Complete data on a line of: hydraulic power units, including the electric, hand-operated, and power-driven models; piston-type pumps, both 15 hp, 6 piston wobble plate pump, and the 5 hp twin-piston pump; selector control valves; hydraulic rams; and auxiliary valves.

(8) PUSH-PULL CONTROLS—American Chain & Cable Co., Inc., 5 booklets, 20 pp. Covers all types of push-pull controls, including: heavy duty hand-operated assembly; bracket type head controls (friction, ratchet, positioning and positive lock head); heavy duty micro control series; and standard assemblies. Has installation diagrams, construction features of each type, and graphs showing input load in relation to degrees of bend.

(9) HIGH TEMPERATURE ADHESIVE—Narmco Resins & Coatings Co., Bulletin NRC-504, 2 pp. Has application, curing, surface preparation data and test results of the Metlbond 4021 adhesive. Tensile shear values of 2,000 psi at 260 F after 100 hours were exhibited.

(10) STEEL CASTING SELECTION GUIDE—Lebanon Steel Foundry, Slide Rule. Called the circle L slide chart, it gives facts on steel casting material selection and reference data on 19 carbon and low alloy grades, and 17 stainless and corrosion resistant grades. Adjusting to the proper grade gives the nominal analyses, the

A NIGHTMARE TO MACHINE



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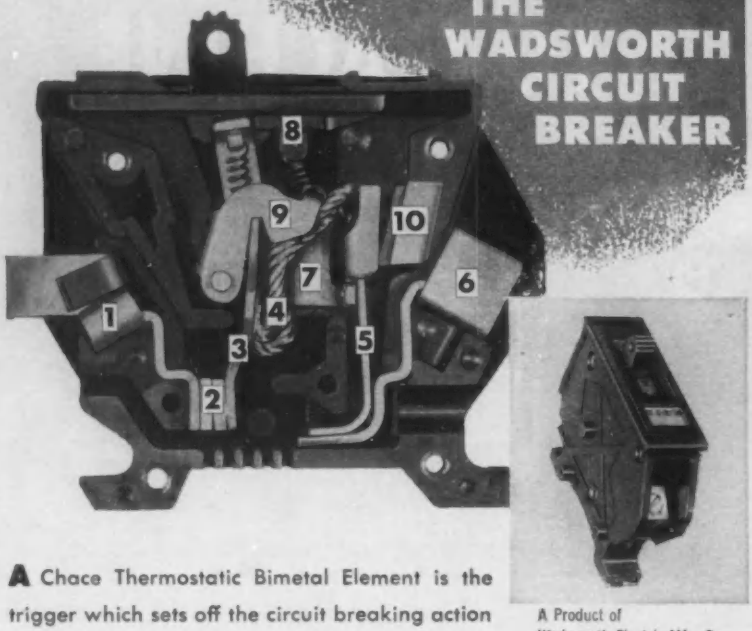

A Product of
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Covington, Kentucky

A Chace Thermostatic Bimetal Element is the trigger which sets off the circuit breaking action in the Wadsworth Thermal-Magnetic Circuit Breaker when an electrical overload occurs. The Wadsworth unit operates automatically or manually and features the "E-Z-Red"® indicator which shows clearly when the circuit has been opened automatically.

The line connection to the unit is indicated by (1) in the cutaway view. The current passes through contacts (2), switch arm (3), pigtail (4), Chace bimetal element (5) and through solderless connector (6) to load terminal.

An increase of temperature because of short circuit or overload causes Chace bimetal element (5) to flex to right, releasing latching ear (7). This allows spring-loaded rocker (9) of which (7) is a part, to move counter clockwise. Switch arm (3) follows due to tension of the spring, and over center action opens contacts (2). The "E-Z-Red"® indicator (8) projects at the same time to indicate the breaker has tripped automatically. Magnetic element (10) accelerates flexing of bimetal at beginning of operating cycle.

Leading builders of temperature responsive devices throughout the world specify Chace Thermostatic Bimetal in their products. If your product controls or indicates temperature changes, you will be interested in our new 36-page booklet giving 22 uses of thermostatic bimetal and data on element design and selection. Write for it today.

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minimum mechanical properties, and the heat treatment. Also gives comparable ACI, AISI, ASTM, Hydraulic Institute, SAE, Military, and Federal designations.

(11) ADJUSTABLE V-BELT—Manheim Mfg. & Belting Co., Booklet, 8 pp. Fully illustrates and describes the new Veeloss TD and TE adjustable V-belt for D and E belted drives. Explains installation and operation characteristics. A v-belt length table, showing correct lengths for this v-belt are compared with endless v-belts.

(12) ENCAPSULATION RESINS—Aries Laboratories, Inc., Bulletin, 14 pp. Describes the use of Airtemp casting resins for the encapsulation and embedment of electronic components and circuit assemblies. Have good adhesion to metals and plastics, and have low moisture absorption and vapor transmission. Used in temperatures from —60 to +200 C.

(13) NEEDLE BEARINGS—The Torrington Co., Catalog 61. Has basic technical data, facilitating the selection of the proper bearings for any installation. Has many cross-section drawings showing the details of typical installations. Also covers design features, bearing selection, sealing, and lubrication. Has tables on speed and life factors, as well as capacities, and hardness factors.

(14) ALUMINUM MILL PRODUCTS—Reynolds Metals Co., Booklet G3-17-853, 12 pp. Has data on the characteristics of aluminum, standard alloys, tempers and sizes of sheet, plate, wire, rod, bar, tubing, pipe, and extruded shapes. Also lists an alloy selection guide for both wrought and cast alloys. Has alloy selection guide, applications and illustrations.

(15) ELECTRONIC COMPONENTS—Centralab, Catalog 28, 34 pp. Has complete selection data on a line of controls, switches, capacitors, printed electronic circuits, and steatite insulators. Illustrates all types, has wiring diagrams, and gives capacity ratings.

(16) PUMPING PROBLEMS—Geo. D. Roper Corp., Booklet 3060, 36 pp. Explains operation of rotary gear pumps, has factors of pumping prob-

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SURFACE ROUGHNESS . . . *this vital factor in product cost and performance is now easy to control*

Designers have long recognized that surface roughness affects product appearance, tolerances, tool life, friction, lubrication, and many other characteristics. Yet, until recently, surface roughness measurement has been largely a laboratory operation.

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lems and gives several problems. Technical data covers: friction loss in pipes and fittings; cylinder displacements; viscosity oils and conversion charts; specific gravities of liquids; electrical data and conversion tables head to pressure. Has many illustrations, graphs and tables.

(17) POWDERED METAL PARTS & BEARINGS—Chrysler Corp., Catalog B-44, 168 pp. Has complete data on Oilite parts, including: bearings; bronzes; iron; aluminum; machine parts; filters; cored and bar, strip and plate stock. Has many illustrations; load rating charts of each material; tolerances and specifications; and size lists of the plain, flange, and thrust bearings, in various metals. Also has hints on machining and lubrication of this metal.

(18) AIR & HYDRAULIC CYLINDERS—Hydro-Line Mfg. Co., Catalog, 32 pp. Contains complete engineering data for a line of cylinders for operating pressures to 1,500 psi. Cross-sectional views show construction features, and line drawings and all necessary dimensions are given for all models for seven types of mounting.

(19) LUBRICANT APPLICATION DEVICES—Lincoln Engineering Co., Catalog 91, 24 pp. Lists all types of grease fittings for use on original equipment. Illustrates with photo and cross-sectional view each type, including: straight, angle, taper, thread straight and angle, drive type straight and angle, and leakproof fittings. Also shows set-up for centralized lubrication system.

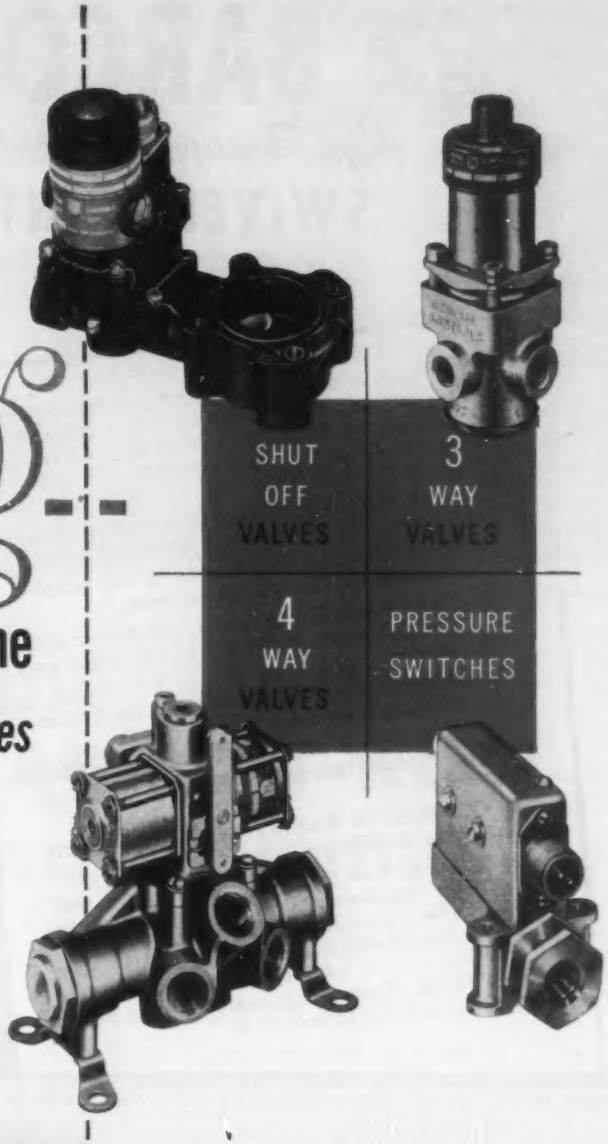
(20) HYDRAULIC SERVO PUMP —Vickers, Inc., Booklet SE-15, 20 pp. Has a detailed description of the electro-hydraulic servo pump and its subassemblies. Has sinusoidal velocity response: amplitude and phase graphs for each model, and graphs showing transient velocity response. Has colored diagram showing hydraulic transmission, showing all feed-back system and all components.

(21) CENTRIFUGAL & TURBINE PUMPS—Aurora Pump Co., Booklet, 8 pp. A selection guide and index to a line of centrifugal and turbine pumps. Illustrates and gives specifications for

hi-g

for any machine

that rolls, floats, or flies



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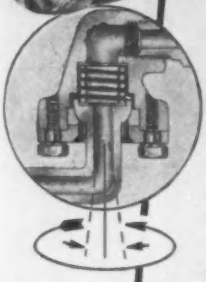
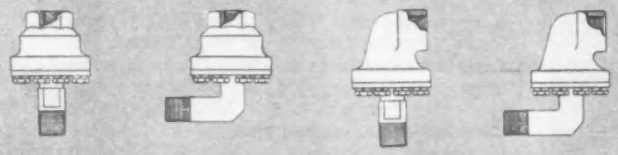


THERE is no question about *performance* when you use Barco Swivel Joints designed for 3,000 psi hydraulic operating pressures. Barco's *exclusive* design gives you these important advantages:

- NO BINDING! Thanks to *side flexibility*, combined with 360° swivel (rotating) action.
- SELF-ALIGNING! Speeds up and simplifies installation. Guards against wear.
- LEAKPROOF! Precision machined and ground ball seats perfectly at any angle on flexible seal.
- EASY TURNING! Moves freely even when fully pressure loaded.
- ABSORBS VIBRATION! No metal-to-metal contact through joint. Moves in any direction.
- CORROSION RESISTANT! Offered with materials suitable for corrosive service.

Designed to meet the most critical aircraft and ordnance requirements, Barco High Pressure Hydraulic Swivel Joints are available in a complete range of standard and specially designed styles and sizes for INDUSTRIAL APPLICATIONS. *Barco Engineers are at your service; ask for information.*

STANDARD STYLES—Steel or Aluminum Casing with Stainless Steel Ball



Connections: AN, Industrial Ermeto, or Standard Pipe Threads

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The Only Truly Complete Line of Flexible, Swivel, and Revolving Joints

FREE ENTERPRISE—THE CORNERSTONE OF AMERICAN PROSPERITY

each model, and has a color selection table showing how many gpm each type of pump and will deliver under various head capacities.

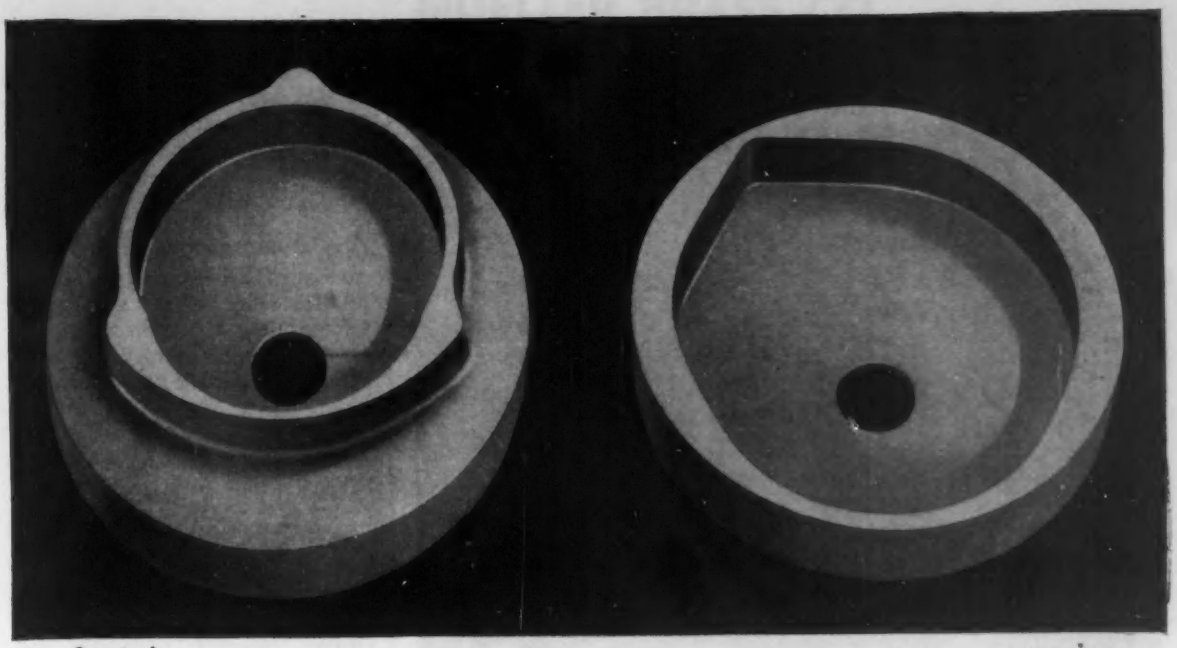
(22) NONFERROUS ALLOY SPECIFICATION—Shenango-Penn Mold Co., Bulletin 154. Has a detailed alloy chart showing comparative specifications, chemical analyses, and the minimum physical properties of nonferrous alloys. Castings available in metals including: tin; bronzes; aluminum bronzes; manganese bronzes; brass; silicone bronzes; special alloys; and Monel metals. Also has a comparison between Navy, Military, Federal, SAE and ASTM specifications.

(23) AUTOMATION OF MACHINE TOOLS—Turchan Follower Machine Co., Booklet, 24 pp. Gives principles of automation, hydraulic servo-control systems, and application of control systems. Has schematic diagrams of open cycle plus feedback; open manual cycle; and closed automatic cycle. Has detailed diagrams of automatic controls on different types of machines, and illustrates other tracer-controlled machine tools.

(24) FLEXIBLE CABLE CONTROLS—Teleflex, Inc., Bulletin 500, 16 pp. Describes a mechanical system using a rack-like flexible cable within a smooth, rigid conduit. Transfers linear or rotary motion without intermediate links or pulleys. Procedure for laying out a control on linkage is also suggested.

(25) MECHANICAL MEASUREMENT TECHNIQUES — Hewlett-Packard Co., Bulletin, Vol. 5, No. 1-2. Describes methods for making common mechanical measurements with electronic counters. Discusses measuring operating time of high speed clutches, rpm on high speed shafts, relay operating times, stability of rotation; also, measurement of pulse duration, linear velocity, flow, wave-forms, and others. Schematic and circuit drawings are included.

(26) EXPLOSION CHAMBERS — Teney Engineering, Inc., Bulletin 3370-5M, 4 pp. Data on a new explosion chamber that may be used to determine the effect of explosions on materials, components, sub-assemblies or complete units; or to determine



front view *rear view*

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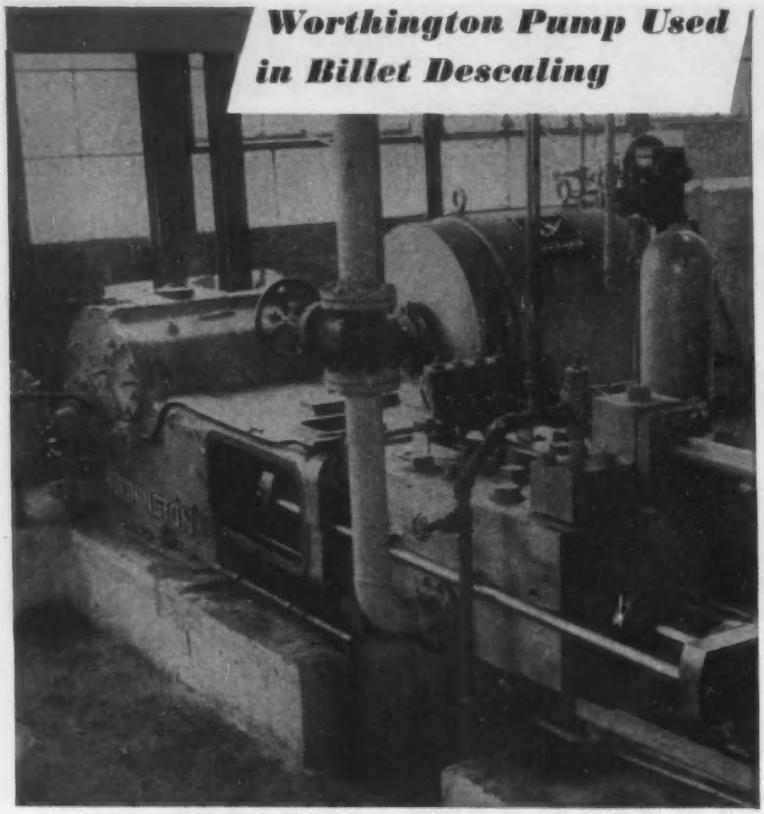

Worthington Pump Used in Billet Descaling

is powered by Star-Kimble Motor

This Worthington 2¾" by 12" plunger pump, shown installed at the South Bend Plant of the Oliver Corporation, produces the pressure needed to force water through the nozzles of a Worthington descaling system. Billets are fed into the descaling cabinet at the rate of 125 an hour. To maintain uninterrupted production flow at this rate of descaling calls for an unfailing supply of water to the nozzles of 110 gpm at 2,500 psi. To power the pump for this service, Worthington selected a Star-Kimble squirrel-cage motor.

IN ADDITION

Star-Kimble designs and builds special and standard motors — squirrel-cage, wound rotor and d-c types — to meet specific requirements in all major industrial fields of motor application, including machine tools, marine, materials handling and processing equipment.

For information on standard squirrel-cage motors, write for Bulletin B-201.

Standard and special motors of all types, 1 to 125 hp; generators and motor-generator sets, 1 to 100 kw; Marine motors ½ to 125 hp.

Star-Kimble
MOTOR DIVISION
of Miehle Printing Press and Mfg. Co.

Bloomfield Avenue Bloomfield, New Jersey

whether equipment will cause explosions when operated in an explosive atmosphere. Lists specifications, features, construction details, and procedures for testing.

(27) MERCURY SWITCHES—Micro Switch, Catalog 90, 12 pp. Covers standard designs of mercury switches for use in a-c or d-c industrial and commercial switching applications that provide low force and tilt motion. Covers five classes: protected; heavy duty; general use; small; and sensitive. Has data on: dimensions; rating; differential angle; and type of application.

(28) LIGHTWEIGHT STRUCTURAL MATERIALS—Rolle Mfg. Co., Booklet, 16 pp. Discusses the use of lightweight structural materials, including aluminum, magnesium and Fiberglas in product design. One section is devoted to Fiberglas laminations, how they are molded and important factors in their design. Methods of forming metals are discussed in detail, with stress on sand and permanent mold casting procedures.

(29) PRESSURE-TIGHT CASTINGS—The Meehanite Metal Corp., Bulletin 43, 48 pp. Contains 64 illustrations of specific industrial applications of castings where absolute density, uniformity and resistance to various pressure ranges is necessary. Also has some engineering property charts and pressure casting design suggestions.

(30) TWO STEP TIME DELAY RELAY—Elastic Stop Nut Corp., Bulletin SR4, 4 pp. Information on a pneumatically controlled time delay relay, designed to introduce either a sequence of time delay periods, or a momentary impulse, into an electrical circuit. Two types: with delay beginning when coil is energized; or when the coil is de-energized. Booklet has wiring diagrams and selection data.

(31) FLEXIBLE COUPLINGS — Lovejoy Flexible Coupling Co., Bulletin 1009, 20 pp. Illustrates types and sizes for every service, with load ratings from fractional to over 800 hp. Spider-type couplings at ratings from fractional to 40 hp at 1,750 rpm. Cushion-type couplings begin at 2.58 hp at 100 rpm. Has illustrations, engineer-

ing drawings, and specifications for all types. Also has varying or pulsating load conversion table, and horsepower to torque conversion table.

(32) ENGINEERING GRAY CAST IRONS—International Nickel Co., Inc., Bulletin A-174, 52 pp. Explains the proper principles necessary for the production of as-cast acicular iron having tensile strengths of 60,000 to 80,000 psi, and when heat-treated up to 105,000 psi. Has many photomicrographs, charts and tables.

(33) AIR & HYDRAULIC CYLINDERS—The Hydraulic Press Mfg. Co., Catalogs 701, 721, 741, 98 pp. Has complete specifications on: a line of air and hydraulic cylinders for 150 psi air and oil; hydraulic cylinders for 3,000 psi; and hydraulic cylinders for 3,000 psi. Has data on various mountings, capacities, and sizes, plus several cutaway views and many illustrations of each model.

(34) INDUSTRIAL WIRE CLOTH —National-Standard Co., Catalog, 64 pp. Has information on the many types, sizes, and applications of wire cloth. Illustrations are given of each kind, along with the sizes and weights. Complete information is given on special weaves, square and fine mesh wire cloth, filter cloth, selecting and testing, calculating weight, suitability of metals, properties of metals, protective coatings, and wire gages. Has many charts, tables, conversion factors, and data on other metals.

(35) VIBRATION ISOLATORS— The Barry Corp., Bulletin 537, 4 pp. Presents detailed technical and application information on the series 262, and 633 vibration isolator mounts for light industrial applications. Data includes: dimensions and load ratings; installation procedure; variation of natural frequency with load; and percent efficiency of isolation.

(36) MOTOR CONTROL — Allen-Bradley Co., Catalog, 120 pp. Has complete description and specifications for a line of: d-c apparatus; drum switches; rheostats, speed regulators; a-c manual starters; a-c magnetic starters; push-button limit switches; accessories; and synchronous starters. Has illustrations of each, along with ratings, and other data.

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Ad Libbing by the Editor

Once there was a philosophy, or perhaps it was a school of philosophy, that enjoyed posing brain teasers of a peculiar variety. I believe they had a name for the kind of "reasoning" they used. As an example, they posed this theory: "It can be proved that there must be many more even numbers than there are odd numbers. If we were to write down all the numbers we would observe that there are exactly the same amount of odd numbers as there are even numbers. But we will then multiply all of the numbers by two and, because twice every odd number and twice every even number is always an even number, we would see that there will be more even numbers than odd numbers." Perhaps by this time the reader has gotten a little dizzy and has discovered that the theory is fallacious. I will leave it to the reader to uncover the fallacy.

Whatever the fallacy may be it is very much in the line of the human failing to attempt to make a long story out of a short one. That reminds me of one of my good friends whom we all called Shorty. Shorty is extremely precise. He hates to waste time. In addition to that he has a brilliant mind.

Now there came a time when Shorty was called upon to hold a committee meeting to decide on whether or not a certain individual was to receive a raise. The other four members of the committee finally got to his office and then Shorty spoke.

"Now before we have this committee meeting on the question as to whether or not Joe Doaks should have a raise I just want to have a little informal chat here and ask you fellows whether your minds are made up and whether you don't think Joe should get a raise. How about it Jack?" And Jack replied that he thought Joe ought to get more money. The other three said about the same thing, all in about three minutes. Shorty's eyes twinkled and he looked at them all and said, "Gee that's swell! We are all in agreement

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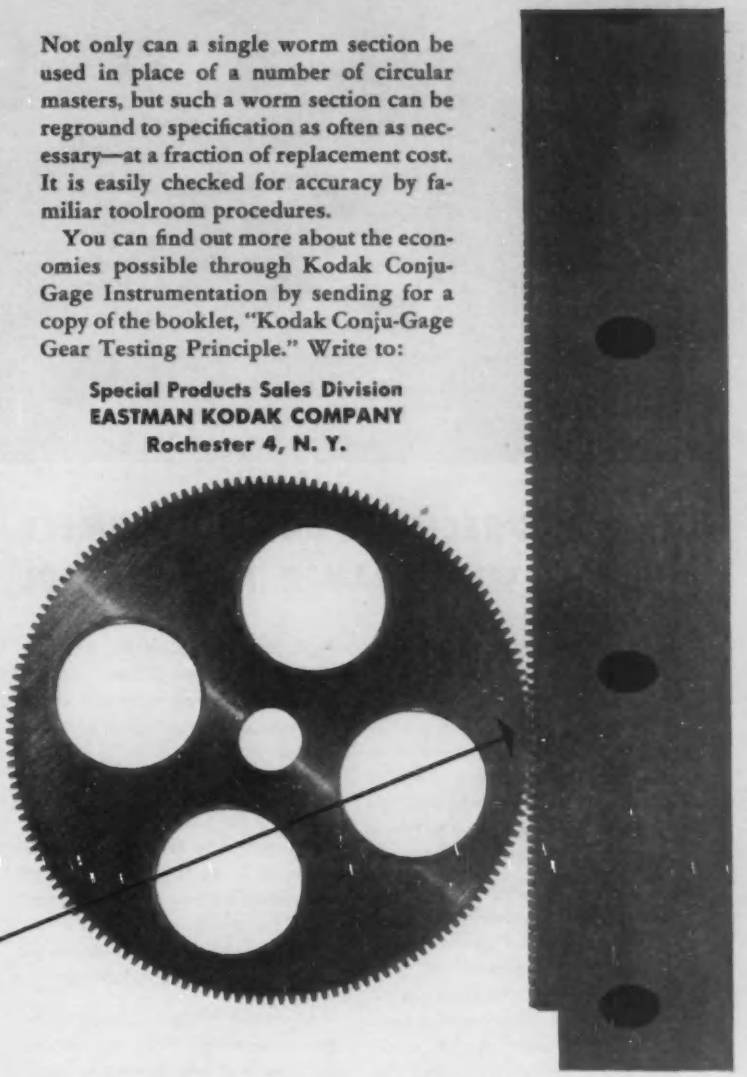

The Kodak Conju-Gage Gear Checker automatically records the composite effects of runout, base pitch error, tooth thickness variations, profile error, lead error, and lateral runout. Illustrated is the Kodak Conju-Gage Gear Checker, Model 4U, for gears up to 4½" pitch diameter. Larger and smaller models are also available.

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that Joe Doaks should get the raise and we don't have to have a committee meeting. I will put through the raise that all you fellows agreed upon."

All of the boys looked very surprised and one of them said, "Aren't we rushing this thing a little bit? Don't you think we should talk it over a bit?" Shorty laughed and insisted that there was nothing to talk over, they had all decided already. In that he was perfectly correct. Shorty had conducted the perfect committee meeting. There was no time wasted in "talking it over." The meeting of the minds was established in a minimum of time. Since that meeting I have often wondered exactly how much time is wasted by "talking it over."

Very often I have noticed that all or practically all of the parties to a committee meeting had already made up their minds, were fully determined on their vote but had a terrific desire to hear themselves talk. So they talked. And the other fellow talked. And everybody talked. And the air in the room got blue with smoke. And still everybody talked. So finally, when they got so hungry they couldn't stand it any longer, they took the vote which was exactly as it would have been if it had been taken at the beginning of the meeting. We should have more committee chairmen like Shorty.

Along this same line is the remark that a friend of mine made to another fellow who had boasted that he had just finished dictating three letters each five pages long. The man to whom he boasted grinned and made the remark, "You don't write letters. You fill pages." Whether it be the written word or the spoken word, there is a natural human failing to be assertive. I guess all of us are subject to it. Depending upon the matter under discussion, we will be tempted in some degree to "talk it up." Personally, I am a great offender in that respect.

Talking about Shorty reminds me of another mutual friend, Mac. Mac is a past master in the art of handling people. I have never heard his voice raised and I have never seen him flare up in anger. Indeed, I have rarely seen him without at least the trace of a smile on his face.

One day I happened to be in Mac's office when his secretary came in to

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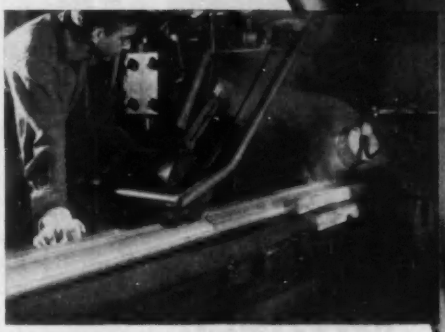

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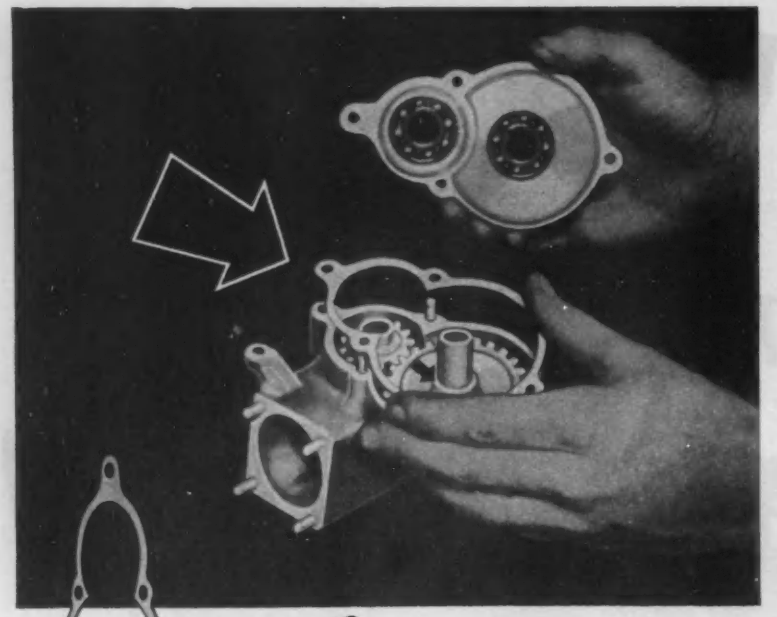

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tell him that a foreman and one of the workmen were outside to see him.

Mac, said, "Bring them in." I got up and excused myself because I sensed that there was some trouble. But Mac insisted that I should keep my seat. Then in came the foreman and trailing after him a very dejected looking shop man. The conversation between Mac and the other fellows went something like this:

Says Mac to the foreman, "Introduce me." And the foreman did so. Mac turned to the fellow, told him to sit down on a beautifully upholstered chair. The shop man hesitated. Mac assured him that the chair was to be sat on regardless of dirty clothes and the fellow sat down. Then Mac said to him, "Now I want you to tell me exactly what happened that caused the piece to be spoiled. If you can tell me that exactly it might be worth a lot to this company."

Well to make a long story short, the fellow went into the explanation. Mac listened tentatively, then asked the foreman whether the inspector didn't check the job between operations, which he should have done, and finally Mac turned to the fellow and said something to the effect that of course everybody was sorry the piece was spoiled, the company was going to lose quite a lot of dough because of it, but the failure was not entirely the shop man's fault. The inspector had evidently not been on the job, and the foreman should have paid a little more attention to him. Then Mac gave him a short but very nice lecture on what he should do to avoid a repetition, shook hands with the fellow and with a great big grin on his face said, "What you have told me is extremely valuable to us. We'll forget all about that spoiled job." That shop man grinned from ear to ear. Where he had come in with a hang dog expression on his face, he now left the room with his head held high.

As we walked out to lunch Mac made a remark to the effect that the shop man was an exceedingly capable fellow. It was the first job he had spoiled and he was very anxious that the man should not get an inferiority complex over the incident or feel that he had better quit. Anyhow, ten years later that same shop man was still there, only he was now running the shop. —G.F.N.

Using Your Patent Counsel More Effectively

CALVIN D. MacCRACKEN*
JAMES M. RELPH*
Jet-Heet, Inc.

OF ALL THE SUCCESSFUL WAYS to reduce product development costs, one of the least practiced and understood is the effective use of the patent attorney. Whether as a resident counsel or on a consulting basis, results show that when permitted and encouraged to work with other members of the product development team, the patent attorney can make many contributions, including: lower engineering costs through faster development; avoidance of mistakes; saving of time; less danger of infringement; better licenses and contracts; and stronger patent protection.

In contrast, however, the average patent attorney's role is pretty much limited to three traditional functions: obtaining patents; advising on infringement problems; and setting up patent licenses. Wherever this definition fits, the chances are good that the firm is paying higher-than-necessary development costs—because it is not using its patent attorney effectively.

Take the planning conference, customarily the first step in any development program. Rarely, in the majority of cases, is the patent counsel asked to sit in. Yet, right here—while the project is being outlined, areas of uncertainty discussed, and solutions proposed—is where the patent counsel can make his first important contributions. This is where he can begin to help save time, cut costs and avoid blind alleys. By his knowledge of the patent art in the field involved, he may offer from expired patents the solution to a difficult problem. Also, he can point out unexpired patents that should be avoided. In any case, he can always arrange for a "collection search" of prior patents that may turn up much valuable information. But to provide this assistance intelligently, he

* *President and resident patent counsel respectively—Jet-Heet, Inc.*

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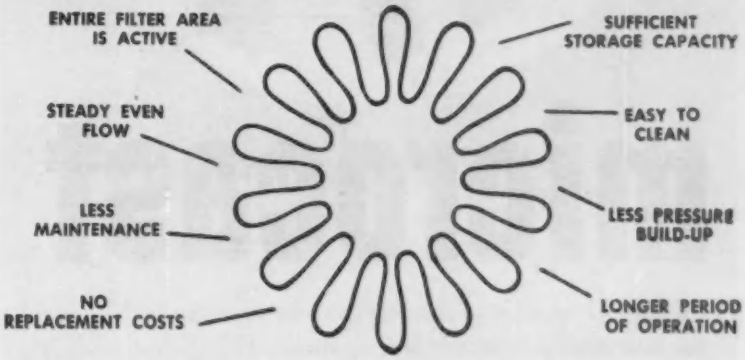

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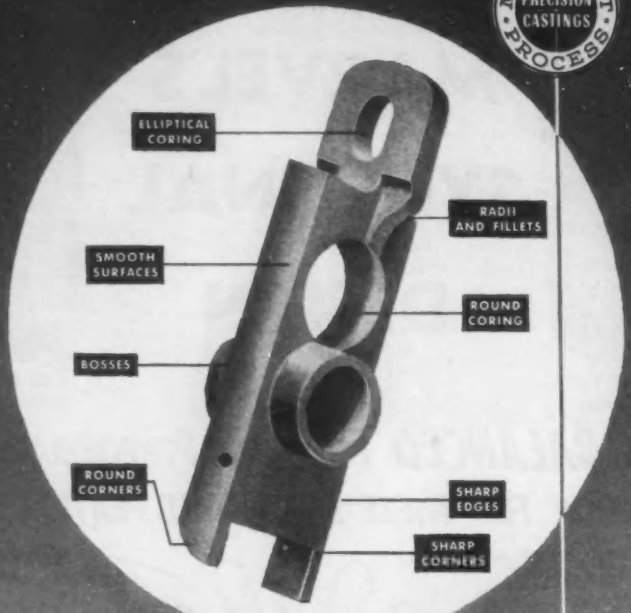

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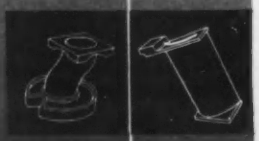

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must be familiar with the problems from the beginning.

In a firm that has license rights under, or ownership of a substantial number of patents, the patent counsel may be able to point out certain patents that can be used to advantage. Particularly in larger organizations, the engineers may not know of all the patents available to them. Certainly, it is unfortunate to design away from protection when it is already available.

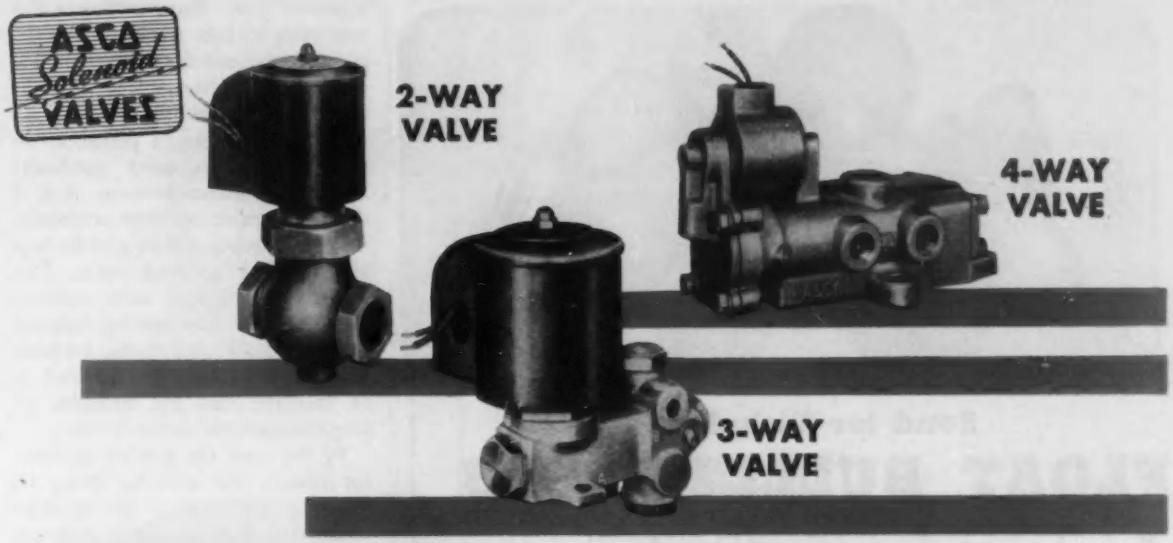
Since the patent attorney does not automatically know all of the engineering answers, and since he is accustomed to thinking in terms of alternatives, his questions at the planning conference and throughout the entire development program frequently will lead to consideration of the unconventional and re-examination of traditional concepts.

At the same time the attorney is making contributions such as these, he is also gaining the detailed knowledge he will need later to prepare and file sound patent applications that provide dependable protection. It is often difficult for the patent attorney to obtain from the engineers, many months later, the detailed information required. The engineer, after long periods of intense association with the problem, understandably tends to leave out details all too familiar to him and not at all familiar to the attorney.

In later stages, such as bench testing of rough models, close contact with the patent attorney should be maintained. Opportunity to watch models in operation and ask questions about them is invaluable.

This approach also tends automatically to increase the disclosures of patentable ideas. In many companies, the engineers are relied on to submit disclosures of inventions to the patent attorney or committee for evaluation and processing. With "patent conscious" engineers who are not under pressure to meet deadlines, this system may work. Ordinarily, however, unless it's an unusual group, the chances are that only a few engineers are submitting all of the disclosures.

But if the patent attorney visits the engineers regularly, disclosures will increase—for several reasons. For one, the problem of writing patent disclosures is alleviated. Engineers are busy, and many begrudge "taking the time." But few object to discussing possibly patentable ideas with the attorney, who can jot down the essential details quickly, without wasting the



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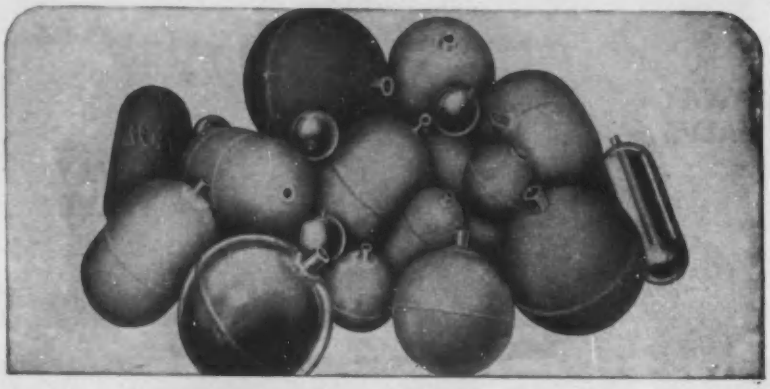

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engineers' time. These exchanges also may bring to light features which the engineer did not think worth a disclosure, thus extending the possibilities of patent protection.

At the very least, a periodical review of the engineers' notebooks should be a matter-of-course. And if the engineers do not keep notebooks, then the attorney will be glad to help set up a proven notebook system. This system should include some "enforcement" procedure for insuring daily use of the notebooks and regular, frequent witnessing. In itself, the notebook is an excellent basis for discussion of progress since the last conference.

By the time the product is ready for release, the attorney, owing to his complete picture of the development, already will have appropriate patent applications under way. And, as improvements are made or considered, he can advise immediately on patentability or infringement questions, without losing time to "study the problem."

When it comes to the actual presentation of claims to the Patent Office, the attorney who has been in on the engineering problems as they arose is far better equipped to secure a strong patent than the attorney who obtained his information by interviews after the job was finished. It is difficult to obtain this information by ex post facto questioning of engineers.

While generally desirable because of its positive benefits, the "ideal" patent attorney-development engineering relationship may be more difficult to achieve in some organizations than in others. Those companies, for instance, who retain an independent patent attorney may have a different coordination problem than firms with resident patent counsel. But in either case, the principles outlined here can be applied to advantage.

In some instances the patent counsel is in full time residence, and an officer of the company. In addition to his regular patent activity, he can also handle the details of the contracts with the customers and the government, including much of the reporting. He keeps close track of all research and engineering work through notebooks, reports and daily contact with the engineers. In this two-way relationship, both patent counsel and engineers are stimulated by discussions, and exchange of ideas and the result is a stronger, more complete patent coverage and lower development costs.

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ENGINEERING ABSTRACTS

Improved Flexural Properties of Reinforced Plastics

Abstracted from "Chlorosilane Finishes for Glass Fabrics" by H. A. Perry, Jr., P. Erickson, I. Silver, and H. E. Mathews, Jr., Naval Ordnance Laboratory, presented at the 9th Annual Meeting of the Reinforced Plastics Division, SPI, Chicago, February, 1954.

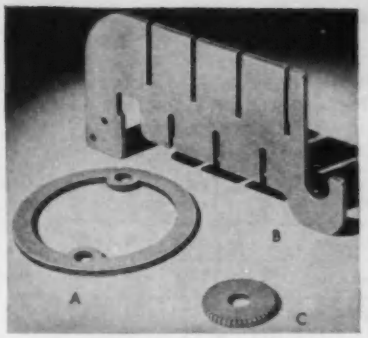
THE USE OF CHLOROSILANE finishes with polyester, epoxy, and phenolic resins, appears to impart significant improvements to various properties of reinforced plastics over those realized with available commercial finishes. These properties include short time flexural strength and stiffness, both wet and dry; resilience, wet and dry; adhesive bonding strength; and creep resistance.

Table I shows the ultimate flexural strength, modulus elasticity and estimated resilience of polyester, epoxy,

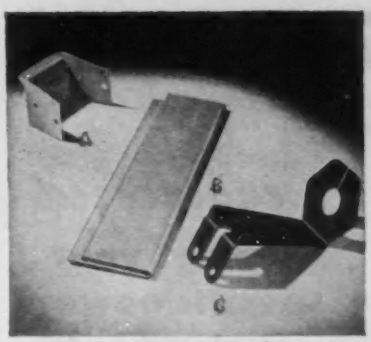
Table I—Flexural Properties of 181 Glass Heat Cleaned Cloth Laminates

		With Best Commercial Finish					
		Polyester Av	Cv	Epoxy Av	Cv	Phen. Av	Cv
Ult Str	D	86[A]	4.5	89	2.3	82	2.7
psi x 10^{-3}	W	63	2.4	72	1.9	85	2.9
Elast. Mod	D	4.1	1.2	3.9	4.0	4.4	1.2
psi x 10^{-6}	W	3.6	2.6	3.6	3.0	4.3	3.7
Resil	D	9	9	10	10	8	8
psi x 10^{-3}	W	6	6	7	7	8	8
		With Best Chlorosilane Finish					
Ult Str	D	96[B]	5.0	109	0.6	108	2.0
psi x 10^{-3}	W	92	2.6	98	4.2	103	2.3
Elast. Mod	D	3.8	0.6	4.8	2.3	4.7	0.8
psi x 10^{-6}	W	3.8	2.2	4.3	10.0	4.4	3.2
Resil	D	12	12	12	12	12	12
psi x 15^{-3}	W	11	11	11	11	12	12

Av = Average of five specimens.
Cv = Coef of variation
A = Wet layup in air; molded at 20 psi
B = Molded with ⅛ in. stops.
D = Dry
W = Wet

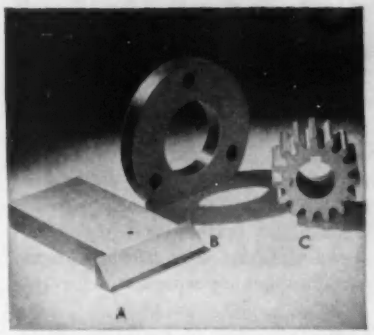


A. Sheet stock, shear strips, punch. B. Sheet stock, shear, punch blank, gang saw notches. C. Sheet stock, shear strips, punch blank, mill notches.

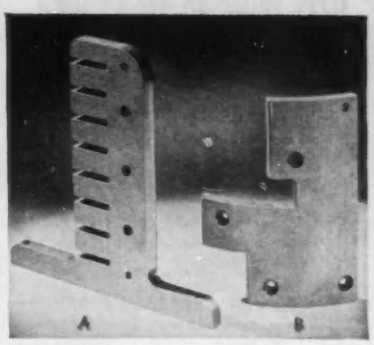


A. Sheet stock, shear strips, punch, form. B. Sheet stock, shear to size, drill, form. C. Sheet stock, shear strips, punch pieces, form in mold twice, rubber stamp twice.

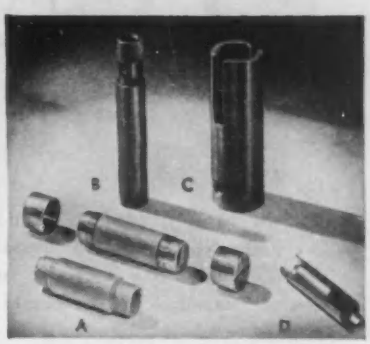
A. Rod (hexagonal), smooth saw, automatic screw machine, turn shoulder thread, champfer and cut off. Remainder are automatic screw machine parts made from Diamond Fibre by C-D-F.



A. Sheet stock, sand, smooth saw to size, smooth saw bevel, smooth saw corner cut out, drill. B. Sheet stock, band saw, turn OD, bore ID, smooth saw side, drill five blind holes with jig. C. Sheet stock, sand, band saw, rough bore ID, hob teeth, finish bore ID, machine keyway.



A. Sheet stock, sand, smooth saw, drill, smooth saw to shape, radius three corners, gang saw notches. B. Sheet stock, band saw rough blanks, form, smooth saw width, length and shape, radius edges, drill with jig, countersink.



A. Tube, automatic screw machine, turn shoulders, champfer and thread end, thread other. B. Tube (long pieces), smooth saw, tap threads, screw machine, (small pieces) auto. screw machine, thread, knurl, champfer, cut off. C. Tube, smooth saw to length, punch twice, countersink. D. Tube, automatic screw machine, champfer, cut off, punch.

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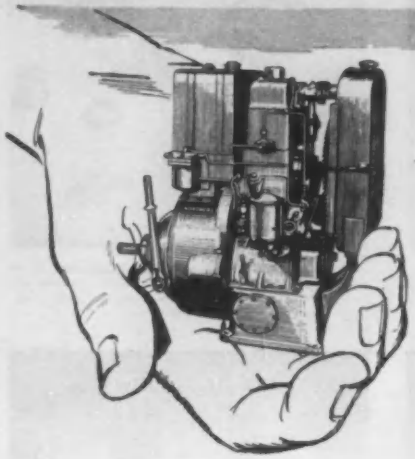

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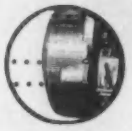

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Table II—Percent Gains, Flexural Properties of 181 Glass Heat Cleaned Cloth Laminates

Resin		Polyester	Epoxy	Phen.	Av.
Ult. Str.	D	+12	+25	+32	23
psi x 10^{-3}	W	+46	+36	+21	34
Elast. Mod.	D	−7	+23	+7	—
psi x 10^{-4}	W	+6	+19	+2	—
Resil.	D	+33	+20	+50	34
psi x 10^{-3}	W	+83	+57	+50	63

D = Dry
W = Wet

and phenolic panels with the best commercial finish and with two chlorosilane finishes. The gains in the flexural properties of the panels with the chlorosilane finishes and the corresponding resins, over panels with existing finishes are expressed as percents in Table 2.

Fracture-Times vs. Finish and Resin. Certain reinforced plastic structures have failed by collapse after a period of time under water pressure. These occurrences have led to a program for the improvement of the creep and delayed fracture characteristics of reinforced plastics, particularly in the wet condition.

Preliminary test data indicate that the fracture time of a laminate, when flexed in water at 150 F, is dependent on the type of resin, on the type of finish and, with epoxy resins, on the type of curing agent. They further indicate that chlorosilane finishes are distinctly superior to those commercial finishes tested to date.

It has been found that a decrease in the stress by a factor of 2 increases the fracture time by a factor greater than 200. Also, a laminate whose fracture time is about 20 hours in the wet condition at 150 F will last longer than 800 hours if maintained in the dry condition at the same temperature.

Adhesive Bond Strength between Laminates vs. Finish. In reinforced plastic structures assembled by means of adhesive bonds, it has been observed that strong adhesives pluck glass fibers from the machined surfaces of reinforced plastics. It has also been noted that the apparent strengths of these adhesive bonds vary with the type of reinforced plastic employed in

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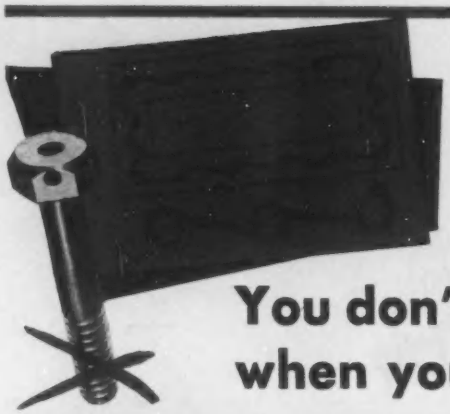

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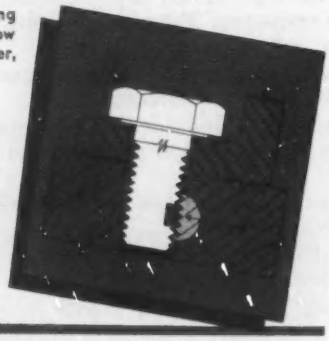

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the structures. Thus, the ability of a reinforced plastic to resist internal fracture due to stresses transmitted to it by an adhesive becomes an important property of that reinforced plastic.

Two types of tests have been conducted in which the apparent strength of adhesive bonds, incorporating sections cut from a laminate, was compared with the flexural strength of specimens cut from the same laminate. A variety of laminates was selected for these tests, including some with experimental chlorosilane finishes.

In the first set of tests the stress was parallel to the plies, and fracture occurred in the bond between one of the laminate strips and the adhesive. Glass fibers could be seen adhering to the adhesive, which were plucked from the end of the laminate. In the second set of tests the stress was normal to the plies and fracture occurred between plies in the laminate. In both tests, low values are associated with poor finishes, and the high values were obtained with the better chlorosilane finishes. Also, the polyester laminating resins showed the lowest bond strengths, even with the best finish now available for polyester resins.

Designing Magnesium Products

Abstracted from "Designing Magnesium Products" by W. Z. Jarmicki, Chief Engineer, Dominion Magnesium Limited. *Modern Metals*, January, 1954.

WHILE THE MOST IMPORTANT FEATURE of magnesium is its light weight, weight reduction of magnesium products is not governed by this physical property alone, but by a combination of it and several others. With the proper application of these properties, the cost of magnesium products can be made competitive with that of products fabricated from more common materials.

Factors to be considered in the design of magnesium products are:

1. Choice of a product to be fabricated of magnesium
2. Loading conditions
3. Required safety factor
4. Stress analysis

In general, magnesium should be used for those products in which a large amount of labor is required per cubic foot of product. In this type of "heavily fabricated" application, labor

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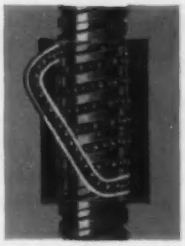

One of these days, when you hop from home to the office in your personal helicopter, you'll marvel at the way you "shift gears"... from "straight up" to "full speed ahead"... from "side-winder" to "hover". It will be done fast, smoothly, accurately.

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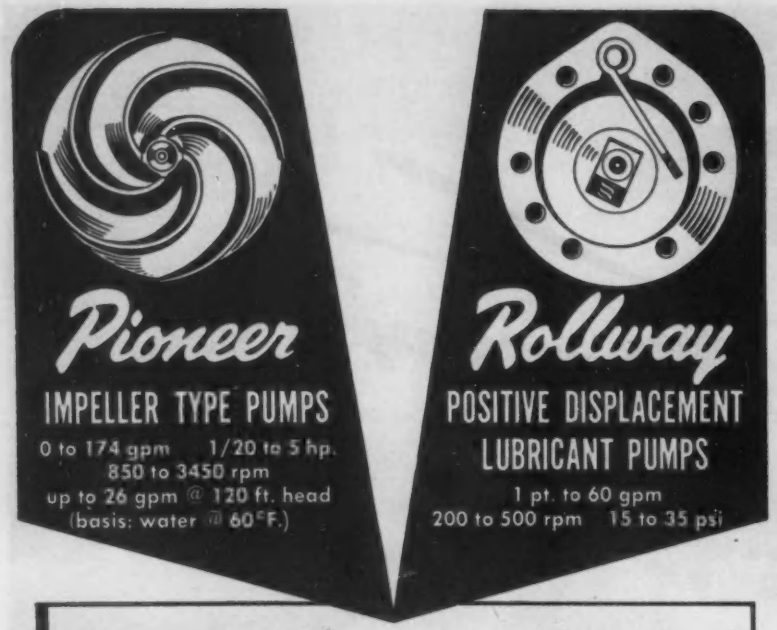
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is a high proportion of the cost, and the relatively high cost of magnesium has a smaller influence on total cost. For example, if a cast product in steel or aluminum requires the same amount of work as a magnesium product, the latter—if it is properly designed—is usually economically feasible.

Minimum weight in magnesium parts is important not only because of the weight reduction but also because of the price. The most effective means of reducing weight depend on factors 1, 2 and 3 listed above.

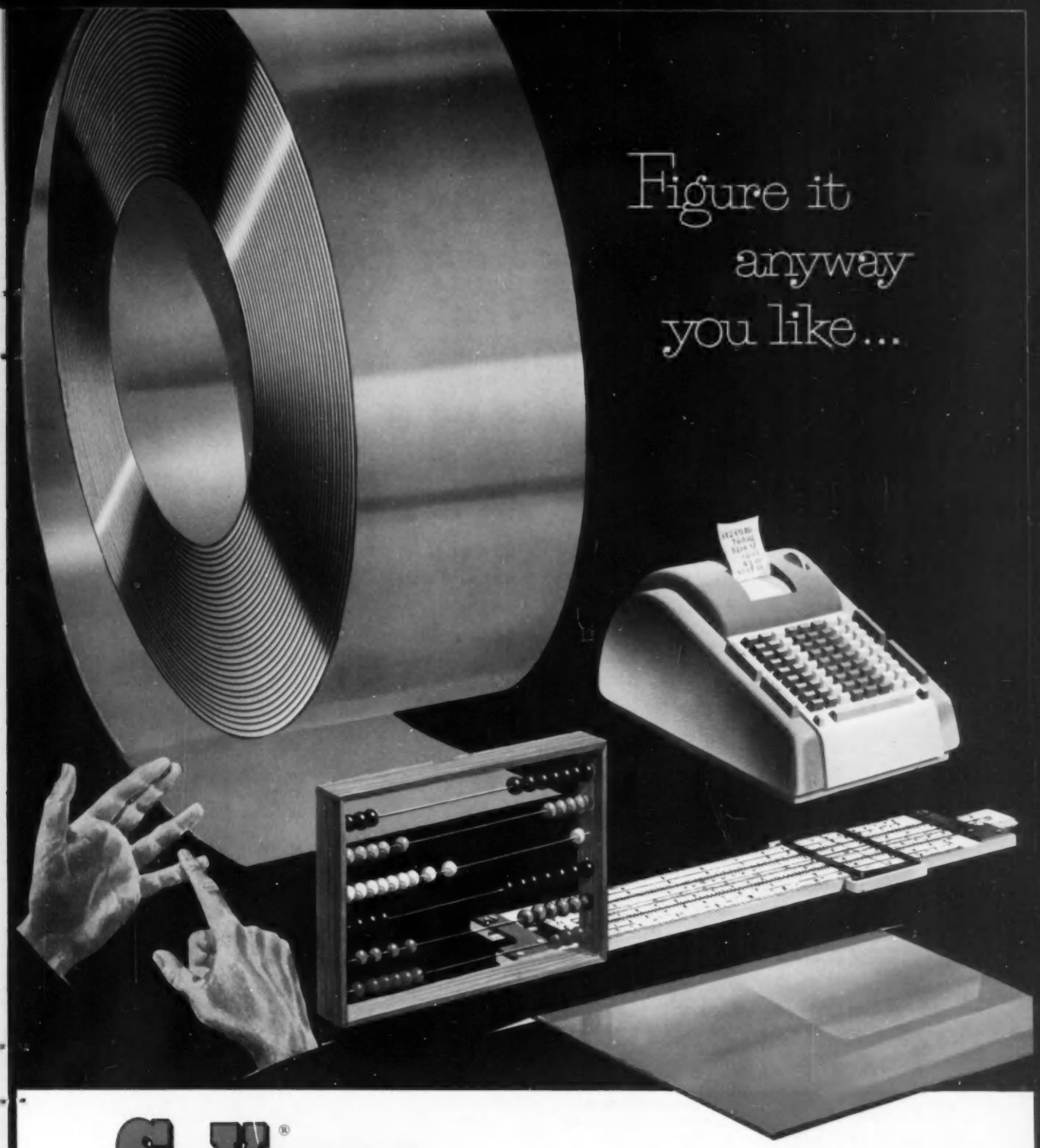
Loading Conditions

The greater the precision with which the loading factor is determined, the lower may be the safety factor. Also, a design based on more accurate stress analysis will permit a lower safety factor. The formulas used in stress analysis are identical for all structural materials; however, the ultimate success of a magnesium product is achieved only if the good features are utilized in the design and allowances are made for the seemingly weak points, like modulus of elasticity and differentiation in compresion and tension.

While for most uses it would be desirable if magnesium had a higher modulus of elasticity, there are applications where the low modulus is an advantage. For example, where large plates are to be connected, the low modulus might permit the omission of expansion joints without an increase in weight. Another application might be for cantilever beams which are impact loaded at the outer end. Here the combination of low modulus of elasticity and the yield strength for this type of load allows the magnesium beam to replace either aluminum or steel beams with a weight reduction of about 30 and 70 percent respectively.

Other design techniques that have made magnesium products competitive with aluminum and steel products are the possibility of using adhesive bonding for light weight assemblies, and the use of extruded magnesium shapes.

Adhesive bonding gives a lighter and cheaper product in certain types of assemblies where large quantities are required. It also has advantages of smoothness and lightness in joining tubular magnesium components that are not obtained in riveted joints. Riveting can cause distortion because



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Because Rubatex cannot absorb moisture, oxygen, dust or dirt, even at cut edges, it positively seals out elements which plague air-conditioning equipment. Your unit will give longer and better performance — cut down expensive dealer maintenance calls where harmful elements have "gummed-up" the works.

More Customer Satisfaction

Rubatex's sealing assurance for smoother, more efficient operations of your cooling unit will pay you sales dividends in customer satisfaction. And there's nothing better than the "word of mouth" recommendation of your customer to his neighbors and friends.

* Rubatex Closed Cellular Rubber retains inert nitrogen (all the advantages of air without its harmful effect) within its sealed cells to give you an unchallenged, lasting and more positive sealing and gasketing performance.

For air that protects —use Rubatex!

Why not give Rubatex a test? Send details of your application — let us send you samples and recommendations.

Write Dept. PE-3, Great American Industries, Inc., Rubatex Division, Bedford, Virginia.

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PIONEER MANUFACTURER OF CLOSED CELLULAR RUBBER ©

RUBATEX CLOSED CELLULAR RUBBER

of setting of the rivet and buckling under load.

Extruded shapes offer the designer many advantages. With the extrusion process, practically any shape or section can be obtained.

A few factors that influence the strength of extruded shapes are: For best weight-strength ratio, structural shapes used for binding, compression or torsional loads are designed so that the bulk of the cross section area is located farther apart from the center of gravity of the section. Buckling or crumpling of section flanges or ribs is avoided by using generous fillets between flanges and webs and beading of free edges.

With the large number of magnesium alloys that are available, the selection of the proper type often influences the success of a design. For example, magnesium ZK61 alloy was developed especially to obtain the highest strength-weight ratio in airborne and transportation equipment, where weight is a major consideration. While this alloy is more expensive than a conventional alloy such as AZ80x, there are commercial applications where the improved performance and service life obtained with the expensive alloy more than overcome the disadvantage of high initial cost.

Cu-Mn-Sn Alloys Look Promising

Abstracted from "The Structure and Mechanical Properties of Copper-Manganese-Tin Alloys" by J. C. Blade and J. W. Cuthbertson. Reprinted by the Tin Research Institute from *The Journal of the Institute of Metals*, Vol. 82, September 1953.

WITH THE IMPROVING ECONOMIC availability of high-purity manganese, increasing attention is being paid to the possibility of using manganese as a major alloying constituent. Preliminary investigations have shown that copper-manganese-tin alloys of suitable composition compare favorably in color and mechanical properties with copper-nickel-zinc alloys. Also, preliminary corrosion resistance tests have indicated that the manganese alloyed compositions will adequately meet expected service requirements.

In investigating the mechanical properties of copper-base alloys containing 1.5-23 percent manganese and 4-14 percent tin, it has been found

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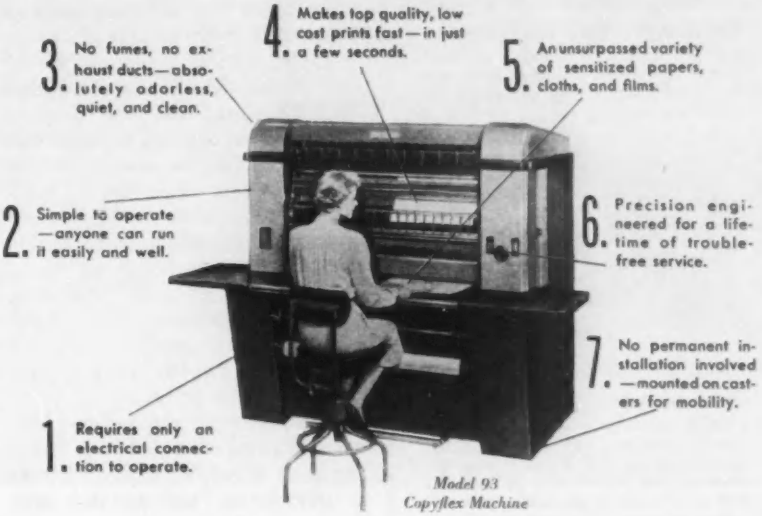
3. No fumes, no exhaust ducts—absolutely odorless, quiet, and clean.
4. Makes top quality, low cost prints fast—in just a few seconds.
5. An unsurpassed variety of sensitized papers, cloths, and films.
2. Simple to operate—anyone can run it easily and well.
6. Precision engineered for a lifetime of trouble-free service.
7. No permanent installation involved—mounted on casters for mobility.
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Today's Copyflex machines represent 25 years of development by men who are thoroughly familiar with engineer prints and print-making requirements. They are made by the Charles Bruning Company, who introduced the diazo type direct process of reproduction in this country in 1929.

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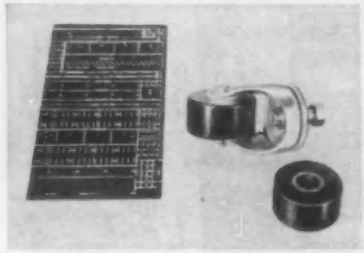
laminated plastics at work

in electrical parts—High dielectric strength of Synthane combined with its light weight is used to advantage in producing high voltage and phase detection equipment.



in business machines—Synthane is valued in the construction of business machines for its light weight, strength, dimensional stability, ease of machining and excellence as an insulator. (Left: plug board for electrically-operated business machine; right: caster wheels.)

in packings—The resistance of Synthane to lube oil, gasoline, moisture, corrosive gases and engine sludge—combined with wear resistance and machineability, makes Synthane desirable for packings of many types, like these by Garlock.

What's your PROBLEM?

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Please send me your free folder describing advantages, properties, uses, and kinds of Synthane plastics.

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that the properties are governed by the total manganese-plus-tin content, not by the contents of the individual metals. Within the composition range investigated, suitable treatments of the alloys give ultimate tensile strengths up to 60,000 psi, with elongations up to approximately 45 percent. Tensile strength can be increased to a maximum of 80,000 psi, but above 66,000 psi the elongation falls rapidly.

Table I shows the tensile properties of alloys tested in strips about 0.07 in. thick and after soaking for 1 hr at 650 or 750 C. Little variation in properties occurs over the wide range of composition, with manganese exerting less influence than tin on the properties. When the alloys are quenched from 650 C and tempered, the maximum hardness obtained increases with the total amount of manganese plus tin. On tempering at 400 C, maximum hardness is reached in 1-30 hrs, according to the composition. Raising the tempering temperature to 450 C reduces to 12 hr or less than time necessary to develop maximum hardness. However, some of the more highly-alloyed metals become very brittle if over-tempered.

Cold working the alloys after quenching from 650 C, the cold working being 50 or 80 percent reduction in cross-section, indicates that little advantage is gained by cold work in excess of 50 percent. If the alloys are tempered after cold rolling, there is still little noticeable difference in the final tensile properties.

Compared to tempering done, superior mechanical properties are obtained when the quenched alloys are first cold worked and then tempered. In particular, alloys receiving the latter treatments are noticeably less brittle, and ductility at a given tensile strength is improved. Table II shows the tensile properties of alloys cold-worked 50 percent and then tempered for different lengths of time at 500 and 550 C. Tempering at 450 C for 20 hr, figures for which are not listed, shows that while the tensile strengths of most of the alloys tested are slightly increased, the elongation drops greatly.

Table I—Mechanical Properties of Quenched Alloys

Composition		U.T.S. tons/in.²	Elong. % in 2 in.
Mn, %	Sn, %		
1.4	9.85	24.8	65
1.4	12.25	26.9	60
1.6	13.75	26.5	33
4.6	10.25	25.2	74
4.1	13.9	32.4	47
7.15	8.4	22.9	57
7.35	8.1*	27.1	67
8.0	10.0	26.5	40
9.0	9.9*	28.8	54
9.6	1.1	24.3	47
9.5	9.7	27.0	63
9.6	11.6	31.0	45
11.5	6.2	23.7	56
14.3	6.0*	26.4	41
13.1	8.1*	27.6	58
14.15	8.2	26.1	43
14.8	5.8	23.3	46
15.9	7.9	25.7	48
19.9	3.9	25.1	46
17.5	5.7	26.1	55
20.0	8.2	31.8	47
23.3	4.6	27.3	43

*—Alloyed with less than 0.14 percent P. Note: Alloys below dividing line quenched at 650 C., those above, at 750 C.

Table II—Mechanical Properties of Alloys Quenched from 650 C, Cold Worked and Tempered

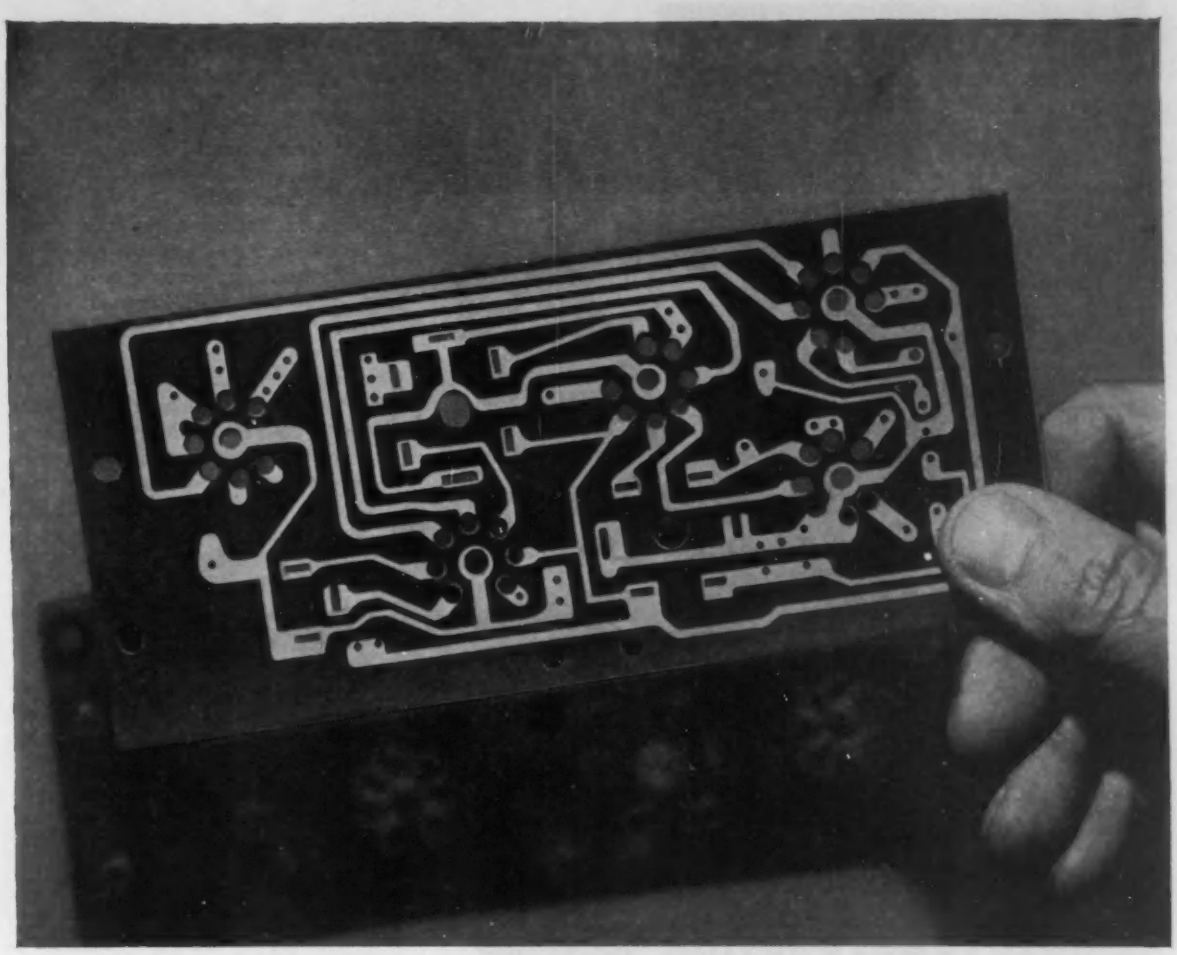
Composition		Tempered for 1 hr at 550 C	
Mn, %	Sn, %	U.T.S., tons/in.²	Elong., % in 2 in.
7.15	8.4	25.1 (29.3)	54 (45)
7.35	8.1*	27.6 (31.2)	54 (33)
8.0	10.0	34.1 (36.9)	21 (5)
9.0	9.9*	21.7 (36.3)	34 (12)
11.5	6.2	25.5 (31.0)	43 (25)
14.3	6.0*	25.4 (32.7)	30 (17)
14.15	8.2	32.9 (38.7)	17 (4)
13.1	8.1*	32.2 (37.9)	24 (7.5)
19.9	3.9	26.9 (28.0)	31 (30)
17.5	5.7	27.7 (32.3)	37 (24)
20.0	8.2	30.5 (35.1)	15 (6)
23.3	4.6	31.2 (32.0)	31 (28)

*—Alloyed with less than 0.14 percent P. Note: Figures in brackets obtained after 50 percent cold working and tempered for 2 hr at 500 C.

High Silicon Irons

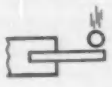
Abstracted from "High Silicon Irons" by Walter A. Luce, the Duriron Co., Inc., Dayton, Ohio, *Chemical Engineering*, January 1954.

HIGH SILICON IRON ALLOYS are characterized by their nearly universal cor-



Pattern of things to come

IN ADDITION TO THE PROPERTIES ALREADY MENTIONED IN THE ADVERTISEMENT, SYNTHANE HAS

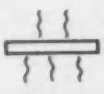


1. Impact strength. Synthane stands up in mechanical applications where jolts, jars and light shock loads are common. It does not splinter or break readily; will not delaminate.

2. Tensile strength. Synthane is strong in tension and compression.

3. Light weight. Synthane has approximately half the weight of aluminum.

4. Flexural strength. Synthane is suitable for jobs where deflexion, torsion and vibration are present. It has excellent fatigue resistance.



5. Stable Over Wide Temperature Range. Synthane is thermosetting; does not flow as temperature rises, has a low coefficient of thermal expansion.

Here is one of the brightest ideas in electronics—and one of the materials which helped make it possible. The idea is the printed circuit; the material is a laminated plastic called *Synthane*.

For years radio sets were put together by laboriously soldering a forest of wires to terminals. It was a time-consuming and expensive operation. If one connection proved faulty, the whole assembly had to be rechecked.

Then someone came up with the idea of *printing* the circuit with an acid-resisting ink on foil bonded to a base—and etching away the metal not needed. It would be quick, easy and error-proof—if the right base material could be found.

Among many tested, *Synthane* was one sheet material selected. Synthane has the necessary strength, low moisture absorption, is an excellent insulator and can be punched easily. It bonds securely to metal foil and withstands the etching acid used to remove the excess metal.

The printed circuit is still in development—but it has zoomed into favor for radio, TV, hearing aids, and many other electronic devices. There are now a dozen ways to produce what are still called "printed" circuits. And Synthane is an accepted base material for every one of them.

Synthane laminated plastics are available in a variety of grades and colors—in sheets, rods, tubes, and fabricated parts. You are invited to write for information to Synthane Corporation, 4 River Road, Oaks, Pa.

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rosion resistance, which makes them adaptable to many exceptionally severe services not handled by any other commercially available metal or alloy (including the entire range of sulfuric acid concentrations to the various boiling temperatures; strong, hot nitric acid; many hydrochloric acid conditions, often to high temperatures; and many mineral organic acids). They are also suitably resistant to most other corrosives normally encountered. The exceptions to this wide range of corrosive coverage include hydrofluoric acid and the various fluoride-containing compounds, sulfurous acid and sulfites. When suitably flushed with water, drain lines will withstand small amounts of these deleterious chemicals without difficulty. Strong, hot alkalis are also damaging to these alloys, although they are suitably resistant under the more mild conditions.

Duriron and Durichlor are two high silicon iron alloys commonly used as chemical equipment. Duriron is a 14.5 percent silicon cast iron. Durichlor contains approximately 3 percent molybdenum in addition to the standard 14.5 percent silicon. The nominal chemical compositions:

	Duriron	Durichlor
Silicon	14.50	14.50
Carbon	0.85	0.85
Manganese	0.65	0.65
Molybdenum	Nil	3.00
Iron	Remainder	Remainder

The presence of molybdenum in Durichlor imparts a high degree of resistance to hydrochloric acid and various chlorine containing compounds, making the alloy better than Duriron in this respect. Durichlor is equally resistant to all other corrosives but is not usually used, because of its higher cost. The percentage of silicon in these alloys is very important for best corrosion resistance.

Mechanical and physical properties of Duriron and Durichlor are similar:

	Duriron	Durichlor
Ten Str, psi	16,000	16,000
Hardness, Brin	520	520
Spec Grav	7.0	7.0
Melting Pt, F	2,300	2,300
Thermal Cond	0.125	0.125
Coef of Exp, 100–300 F	7.33×10^{-6}	7.08×10^{-6}

If your machine has a shaft that must turn at an infinite range of **LOW SPEEDS...**

say 50 rpm to ZERO

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For low speed applications where all speeds are wanted from a maximum of, say, 50 RPM to zero the Graham is especially economical because it incorporates both the speed variation and the speed reduction and avoids the cost and complication of separate gear reducers. For example, on conveyor drives, the Graham Model 150MR7 gives all speeds from 65 RPM to zero and permits taking further reduction, without added cost, by chain.

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The Graham has a performance record of over fifteen years' satisfactory use as standard equipment by leading makers of machines (OEM buyers).

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The Graham is unmatched for accuracy of speed setting and resetting and speed holding. It is "the finest variable speed drive made" but costs no more than conventional drives that do less.

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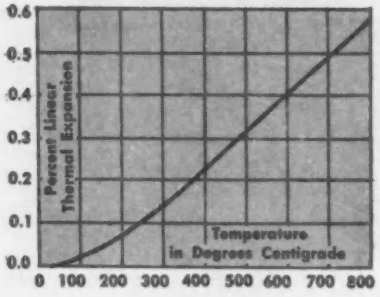
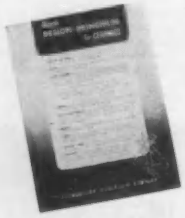


Not only the remarkable heat resistance of Alumina Ceramics but low thermal expansion (like that of Almanox shown above) presents wide design possibilities whether for mechanical, electrical or electronic applications.



For complete information, send for this bulletin on Design Principles and chart of electrical and mechanical properties of FRENCHTOWN ENGINEERED CERAMICS.

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Although these alloys have a fair tensile strength, they resemble all cast irons in that they possess no ductility. In addition, they are susceptible to thermal and mechanical shock and in service must be handled with a reasonable amount of care. These limited mechanical properties make it impossible to produce high silicon iron in the wrought form.

Duriron and Durichlor are available in a variety of cast forms for chemical plant work, including pumps, valves, anodes, strainers and tank outlets.

Heat exchangers, tanks, sections of towers, kettles and S-bend condensors are produced only in Duriron. Special castings can also be made, although the intended application should first be reviewed by engineers trained in the handling of these alloys to make certain that potential difficulties that may be present are not overlooked.

Welding the Alloys

With proper precautions, the simpler forms of Duriron can be successfully welded. Chemical equipment is often fabricated by welding. The oxy-acetylene method is recommended, using a Duriron welding rod and a special flux. The flux can be made by mixing equal parts of lime and sodium bisulfite. For the average welding shop it is not practicable to weld such intricate shapes as centrifugal pump casings or valve bodies. Stresses are developed in the welding cycle, which cause these intricate parts to crack. Prior to welding, the parts should be carefully preheated to approximately 1,600 deg F; after welding, the part should be given a controlled slow cool.

By this means the residual stresses are maintained at a minimum. Durichlor is much more difficult to weld than Duriron and so welding should not be attempted except after considerable experience.

The high hardness of Durichlor and Duriron make them very resistant to many severe erosion-corrosion services. Numerous instances are on record where acid slurries have been successfully handled with Duriron and Durichlor equipment. In most instances, other metals and alloys with good corrosion resistance were applied and were found to be severely eroded. High-silicon iron pumps and valves have been applied for relatively mild corrosive services where an abrasion problem existed.

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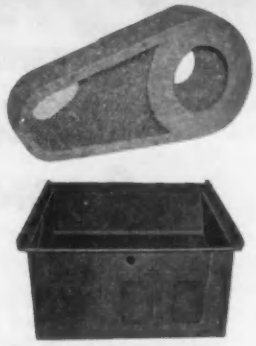

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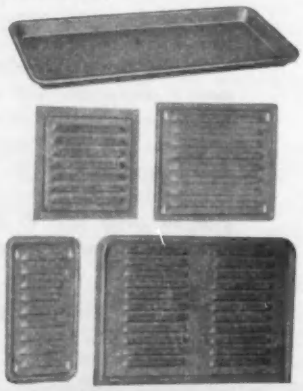

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OUR READERS SAY

Letters should be addressed to The Editor, *Product Engineering*, 330 West 42nd St., New York 36, N. Y.

Extending the Use Of Welded Tubing

To the Editor:

I would appreciate receiving a set of tear sheets on "Welded Steel Tubing in Heavy Equipment," which appeared in your January issue, pages 186-191.

The use of welded steel tubings for equipment, although common knowledge to many engineers, is overlooked in many instances. Structural shapes are considered, or else spinning or drawing. Welded tubing, especially for automotive use, should be thought of more often. I noticed just recently in one of the technical publications that one of the automotive manufacturers is using tubing for the frame of an experimental car. This is an excellent application. After all, welded steel structures have been used on aircraft structures for a good many years.

—J. K. ALLEN
Los Angeles, Calif.

An Answer to A Problem

To the Editor:

After reading Mr. Ward E. Bullock's letter seeking information on planetary gearing, (*Product Engineering*, January 1954, p. 289), I would like to describe a method for the problem he outlined. It is a rather simple device but I've never found it to be wrong.

Mr. Bullock has a 62 tooth held sun in mesh with a 28 tooth plane attached to a 26 tooth planet. This planet then meshes with a 64 tooth output sun. His problem is to determine whether he can use 3 sets of planets or possibly more. All that is necessary is to add the number of teeth in the sun to the number of teeth in planet that is to mesh with it. In this case, 62 + 28 = 90, and 64 + 26 =

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90. Now, if 90 is divisible by a number, n, so that the answer is an integer, then n planets may be assembled to this gearset. For example, $90 \div 3 = 30$. Therefore, 3 planets will assemble. $\frac{90}{4} = 22.5$, thus four planets will not assemble; $\frac{90}{5} = 18$, showing that five planets will assemble, with all teeth properly in mesh. Note—two planets can always be assembled as long as all gears are of similar pitch. A further precaution that should be observed is that all planet clusters should be marked in an identical spot. For example, mark a tooth on the 28 tooth gear which is in exact index with a tooth on the 26 tooth gear. All planets will then assemble properly provided the gears are assembled with index marks in the same position. (Axis formed by the marked tooth and the center line of planet should be parallel for all planets.)

In the above gearset 1, 2, 3, 5, 6 or 9 planets can theoretically be used. However, if a 60 tooth gear were substituted in place of the 62 tooth gear and the other sun also reduced by 2 teeth, then 1, 2, 4 or 8 planets would work.

Incidentally, the Ford Model "T" used similar gears and had three sets of planets, each of which was a cluster of three different gears.

—ANTHONY KUSHIGIAN
Highland Park, Mich.

Indium As a Solder

To the Editor:

Reference is to a small item appearing on page five of your December 1953 issue under "Highlights." This item concerning the use of indium as a solder is somewhat misleading in that it discusses indium in terms of a fluxless solder. This is true only to a limited degree in that a flux may be used with indium on metals below zinc in the electrochemical series, and a flux is usually preferable for bulk metals of this class.

For nonmetals and such metals as titanium, magnesium or aluminum, a flux is not used; in fact, the indium will not wet the surface in the presence of a flux. This fact is presumably due to the removal of the indium oxide on the indium by the flux. This oxide appears to be necessary for the

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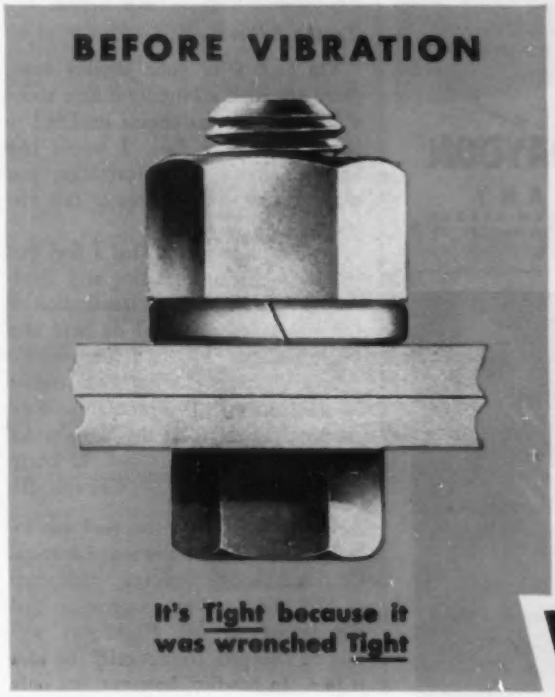

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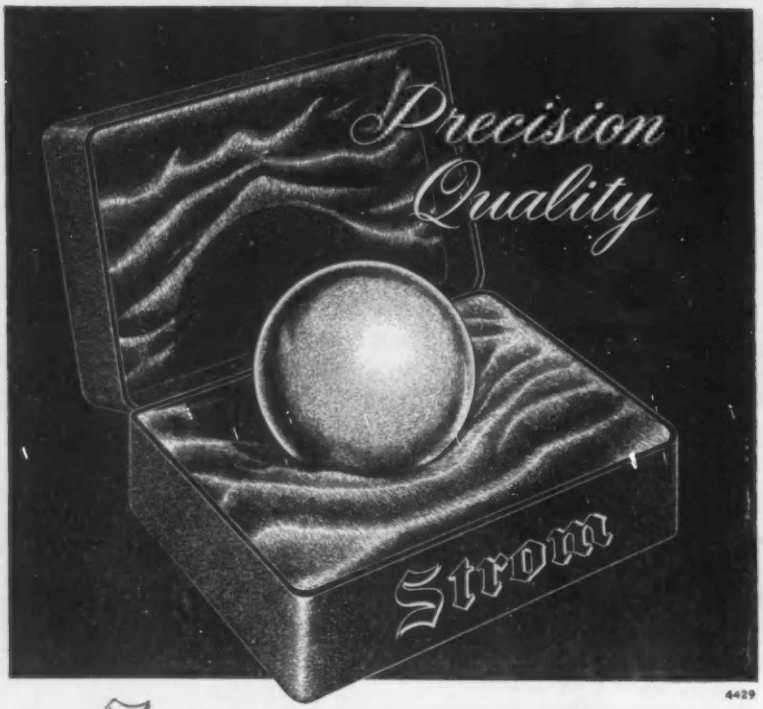

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bonding of indium to nonmetallic surfaces (such as metallic oxides, quartz, glass, mica and related substances) or to metals like aluminum that are normally coated with adherent oxides. —RICHARD B. BELSER
Georgia Institute of Technology

Ed—We're sorry if the item appeared misleading. Care is taken to avoid such occurrences in "Highlights," but occasionally space limitations effect the amount of information that can be given. Thanks for your fuller explanation. We'll try to be more careful.

Highlights: A Query And A Suggestion

To the Editor:

On page 9 of your January issue, there appeared a Highlight item about a conventional gas engine modified to handle hydrazine fuel. I would like and appreciate any information you may have as to the source of this material.

I would like to add that I find this section highly informative and interesting. The method of classification of items is excellent, but I do have one small request. Would it be possible to have all items of a particular nature in one column? This would facilitate clipping and filing of the items under the various headings. —T. L. LONG
Chicago, Ill.

Ed—Information on the fuel can be had from the Mathieson Chemical Co., Mathieson Building, Baltimore 3, Md. As for your suggestion that the layout of the Highlights section be changed, theoretically the idea is fine. In practice, however, not only the quantity, but also the quality of the items would suffer if we tried to confine any group of items to a limited, set form. We're sure that more readers would complain then.

From an "Inactive" Reader

To the Editor:

My compliments on your January issue. As one of your "inactive" readers (I have been retired for several years), may I say that *Product Engineering* is constantly a fine source

of information for me. The articles are well presented in a clear, straightforward manner, done with perception and dignity. They are the best way I have of keeping up with new developments in the design field. Of especial value in January was the fine story on Industrial Optics. At one time I did considerable work in this field and thought there was little I could learn. To my surprise and pleasure, I found a great deal new.

—ARTHUR PENDROLA
Trenton, N. J.

Three Questions

To the Editor:

I should like to have information on three subjects.

1) The use of fittings in structural tube work similar to the railing fittings used with iron pipe. The size tube will be about ½ in. dia. Probably *Product Engineering* has printed articles on this subject, and I'd like to order reprints. Information from manufacturers' catalogs would also be very welcome, but I don't know who makes such products. General information on Tube Fabrication would be very helpful as well, either reprints or catalogs.

2) What Design Work Sheets are now available?

3) How much is a subscription to *Product Engineering?*

—WILLIAM B. STEIN
Barberton, Ohio

Ed—1) You can undoubtedly get the information you want by contacting: the Taylor Forge & Pipe Works, P. O. Box 485, Chicago 90, Illinois; the Crane Co., 838 South Michigan Avenue, Chicago 5, Illinois; or the Ladish Co., 5402 Packard Avenue, Cudahy, Wisconsin.

2) The 11th series of Design Work Sheets is now available.

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The 1954 Handbook

To the Editor:

I have finally received my copy of the *Annual Handbook of Product Design for 1954* and may I take this opportunity to say that it was worth waiting for. Your staff is to be congratulated for a really fine piece of

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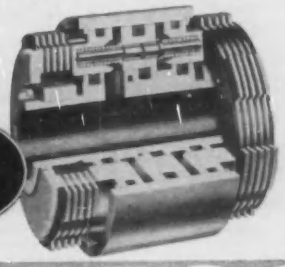

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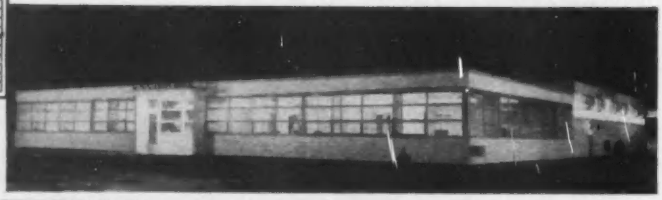

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—ARNOLD GOUGH
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To the Editor:

In the *Annual Handbook of Product Design for 1954*, page D 37, "Developments to Watch," in the paragraph about large die castings, you refer to the die casting of an aluminum engine block. We are very interested in knowing who has the machine for this item. —CARL ROEHRI, PRES.
Federal Die Casting Co.

Ed—We suggest you contact the Doehler-Jarvis Division, National Lead Co., 388 Fourth Avenue, New York, N. Y.

To the Editor:

As a subscriber to *Product Engineering*, I have received a copy of the *Annual Handbook of Product Design for 1954*. After reading the article on "The New Patent Law for 1953," I would like to have more information on the subject. I would appreciate receiving reprints of "Patents and the Engineer," by Col. Toulmin, as presented in the June 1948 and July 1948 issues of Product Engineering.

—F. P. MARCINIAK
Levittown, N. Y.

Help Wanted

To the Editor:

At the present time I am doing a project in "Design and Development" (a senior course) on a Heat Pump. Data on this subject are quite scarce, and I would like to obtain any information that is available on this subject, such as design data, capacity, efficiency and output. I would appreciate very much if you would send me a list of manufacturers that I could contact for such information.

—JOHN A. HOFSASS, JR.
Valparaiso University

Ed—The list is on its way.

To the Editor:

I am trying to gather some data on the gear manufacturing industry but have been unable to find any reliable

sources. Do you have information and/or publications that would help me answer the following questions?

What is the total yearly gear production of the United States in units and dollar value?

What is the total yearly gear production in units and dollar value of the various types of gears, such as spur, bevel, coarse, fine?

What is the total yearly gear production in units and dollar value of gears used in various industries, such as machine tool, appliance, pumps, automotive? —C. C. DENGLER
Modern Manufacturing Services

Ed—We've sent you a breakdown of the figures appearing in the government's "Census of Manufacturers for 1947," the latest figures available on gear production. For further information, it might help you to contact the American Gear Manufacturers Association in the Empire Building, Pittsburgh, Pennsylvania.

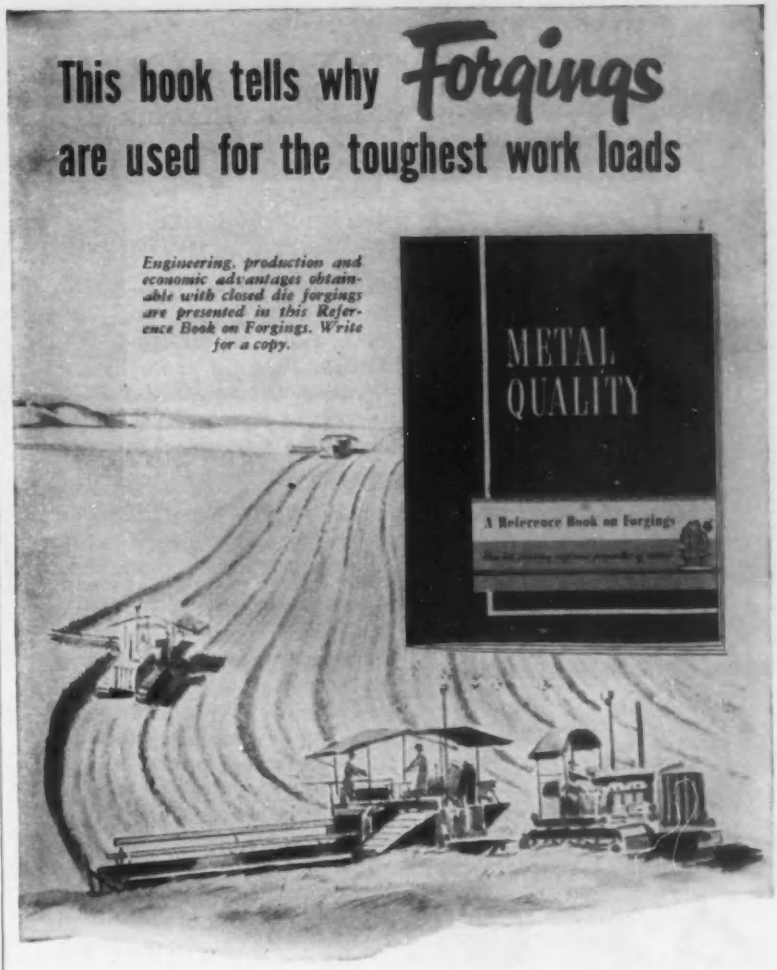
Numbering Systems

To the Editor:

We read with interest your article in the January issue of *Product Engineering* on "Numbering Systems in the Engineering Department." We are very much impressed with the outline presented, which eliminates the need for a cross reference of part numbers to drawing numbers. Do you have other articles along this line, or can you tell us where we could obtain additional information on this?

We would also like to obtain information on how to set up a system for finding a part when the part number is not known. Can you help us in this situation in any way?
—GEORGE SCHNEIDER
Badger Machine Co.

Ed—Sorry, but the January article was the only one we've had on the subject. The best place we can think of to get further data is the Department of Commerce, Washington 25, D. C. As for your second question, one possible answer might be to put together a catalog of photographs of the various parts, grouping all gears together, all fastening devices together, and all parts of the same relative size together. Part identification would then be a relatively simple process.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U. S. Navy Bureau of Ordnance In World War II

BURFORD ROWLAND, *Lieutenant Commander, USNR, and* WILLIAM B. BOYD, *Lieutenant, USNR.* 6 x 9 *in.,* 539 *pp. Published by the Bureau of Ordnance, Department of Navy. For sale by the Superintendent of Documents, U. S. Government Printing Office, Washington* 25, *D. C.* $3.

This is a record volume covering the activities of the Bureau of Ordnance during the war period. Its object is to make available a realistic account of what was done in naval ordnance and how it was done. Problems faced by the Bureau, its accomplishments and its failures are covered. Specifically, this volume is devoted to weapon development and production. Each chapter covers the development of a particular weapon or class of weapons; for example, torpedoes, the VT fuse, rockets and fire control radar. While not of a highly technical nature, it gives interesting background material to those who are involved in the design or production of naval weapons.

Dimensional Methods and Their Applications

C. M. FOCKEN, *Director of the Museum of Applied Science of Victoria; formerly Reader in Physics in the University of Otago, New Zealand.* 224 *pp,* 6 x 9 *in. Published by St. Martin's Press, Inc.,* 103 *Park Avenue, N. Y.* $6.

In this book the author has embarked into a field in which there is no general agreement: the relationship of dimensions to physical processes. A survey of the published books and articles on the subject has led the author to critically appraise the present position of dimensions and to objectively cover three facets of the subject: (1) to show how the proper use of dimensions contributes to the fundamental understanding of physical results; (2) to recommend and to illustrate a useful practical method for applying dimensions and dimensional analysis; and (3) to foster agreement

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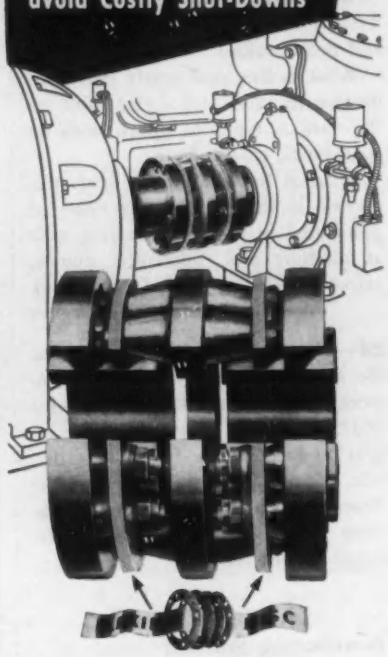

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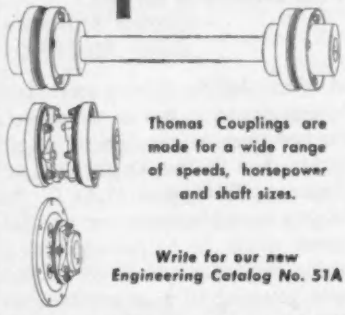

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among all those interested on the subject of dimensions, and in the usage of standard symbols and nomenclature. Also included are several proposals to improve the present position.

The subject matter is written for teachers and students of physics, engineering and allied subjects, and as a "refresher" to those scientists already making use of dimensional methods. Most of the emphasis in the book is on those parts of the subject that are of practical value, the more widely accepted treatment receiving the most attention. Recommended symbols, abbreviations and nomenclature are used throughout as a stimulus for general adoption by writers on scientific subjects.

Six chapters divide the book. Chapter I, an elementary treatment of dimensions, covers the fundamental quantities, units and magnitudes. Chapter II discusses dimensional analysis, starting with the formulation of principles, through the Pi theorem, and ending with O'Rahilly's measure-ratio method. In Chapter III, the author covers the dimensions of various physical magnitudes plus some recommendations and criticisms of dimensional methods.

Chapter IV contains problems in minor physical applications and the applications of dimensional methods to dimensional analysis and theoretical physics. The last chapter, Chapter V, discusses the application of dimensions to model experiments, the use of dimensional reasoning in other engineering applications, and the answers to the series of problems contained in the preceding chapter.

Elementary Differential Equations

LYMAN M. KELLS, *Prof. of Mathematics, U. S. Naval Academy, 6 x 9 in., 266 pp. Published by McGraw-Hill Book Co., Inc., 330 W. 42nd St., New York 36, N. Y. $4.*

This is a new fourth edition of Prof. Kell's book—a combination of theory and applications, valuable for its simplicity, arrangement, and range and excellence of applications. It deals with the most important types of differential equations and explains simply the best methods for solving them. With each type, it supplies exercises ranging from the very simple to the

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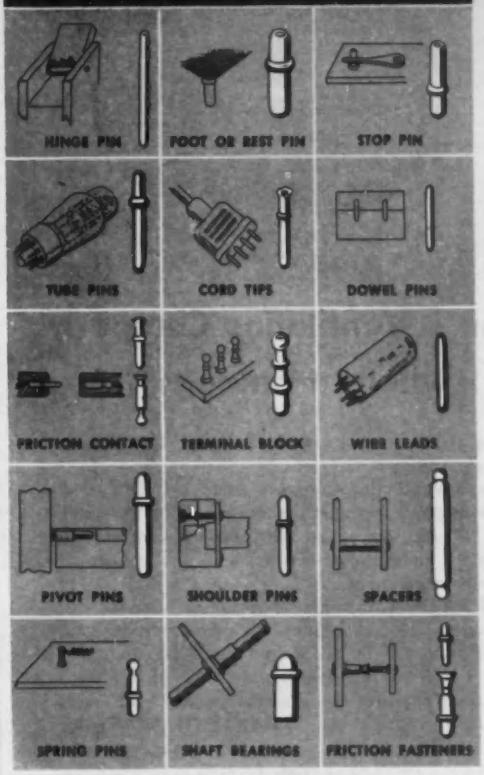

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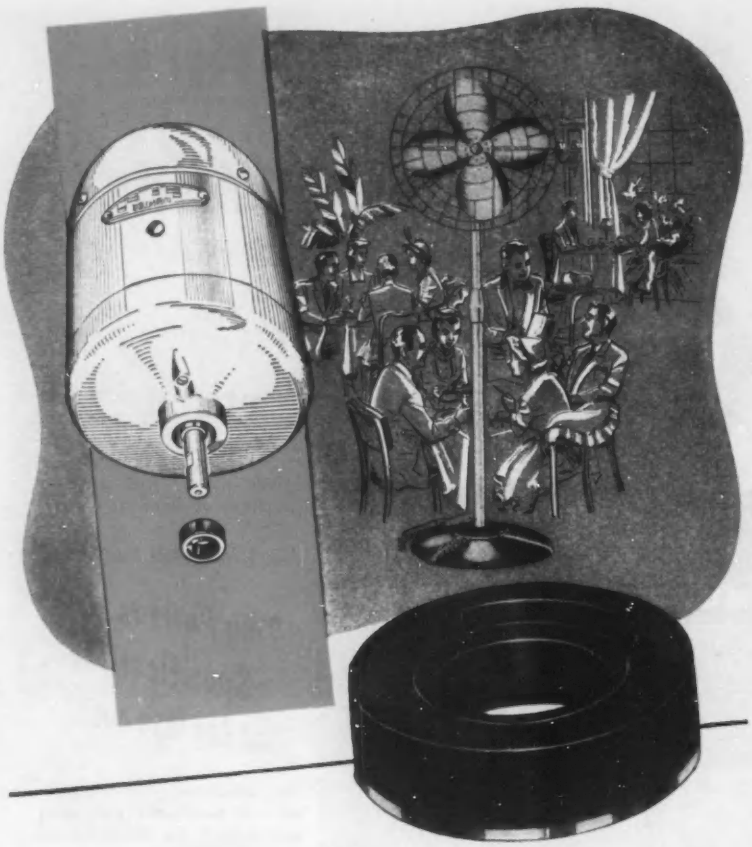

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The Dynamics and Thermodynamics of Compressible Fluid Flow—Vol. I

ASCHER H. SHAPIRO, *Prof. of Mech. Engrg., Massachusetts Institute of Technology.* 6 x 9 *in.*, 647 *pp. Published by The Ronald Press Co.,* 15 *East 26th St., New York* 10, *N. Y.* $16.

During the past two decades a rapid growth of interest in the motion of compressible fluids has accompanied developments in high-speed flight, jet engines, rockets, ballistics, combustion, gas turbines, ram jets and other novel propulsive mechanisms, heat transfer at high speeds, and blast-wave phenomena. The purpose of this book is to make available to students, engineers, and applied physicists a work on compressible fluid motion which would be suitable as an introductory text in the subject as well as a reference work for some of its more advanced phases. The choice of subject matter has not been dictated by any particular field of engineering, but rather includes topics of interest to aeronautical engineers, mechanical engineers, chemical engineers, applied mechanicians and applied physicists.

The basic objective has been to make the book of practical value for engineering purposes. The author has followed the philosophy that the most practical approach to the subject of compressible fluid mechanics is one which combines theoretical analysis, clear physical reasoning and empirical

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results, each leaning on the other for mutual support and advancement, and the whole being greater than the sum of the parts.

The analytical developments of this book comprise two types of treatments: those leading to design methods and those leading to exemplary methods. The design methods are direct and rapid, and easily applied to a variety of problems. Therefore, they are suited for use in the engineering office. The discussions of these design methods are detailed and illustrative examples are often given. The exemplary methods, on the other hand, comprise those theoretical analyses which are time consuming, which generally require mathematical invention, and which are not easily applied to a variety of problems. Such methods are primarily of value for yielding detailed answers to a small number of typical problems. Although they are not in themselves suitable for the engineering office, the examples which they permit to be worked out often provide important information about the behavior of fluids in typical situations. Thus, they serve as guides to the designer in solving the many complex problems where even the so-called design methods are not sufficient. The treatment of exemplary methods in this book usually consists of a brief outline of the method, together with a presentation of those results obtained by the method which illuminate significant questions concerning fluid motion and which help to form the vital "feel" so desired by designers.

In those parts of the book dealing with fundamentals, emphasis is placed on the introduction of new concepts in an unambiguous manner, on securing a clear physical understanding before the undertaking of an analysis, on the rigorous application of physical laws, and on showing fruitful avenues of approach in analytical thinking. The remaining part of the work proceeds at a more rapid pace befitting the technical maturity of advanced students and professionals.

The work is organized in eight parts. Part I sets forth the basic concepts and principles of fluid dynamics and thermodynamics from which the remainder of the book proceeds and also introduces some fundamental concepts peculiar to compressible flows. In Part II is a discussion of problems accessible by the most simple picture of fluid

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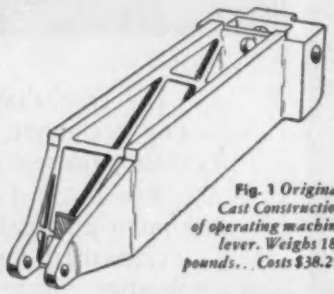

Fig. 1 *Original Cast Construction of operating machine lever. Weighs 182 pounds... Costs $38.25.*

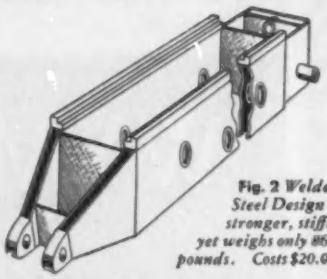

Fig. 2 *Welded Steel Design is stronger, stiffer yet weighs only 86.8 pounds. Costs $20.06.*

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motion—the one-dimensional analysis. Part III constitutes a summary of the basic ideas and concepts necessary for the succeeding chapters on two- and three-dimensional flow. Parts IV, V and VI then present in order comprehensive surveys of subsonic flows, of supersonic flows (including hypersonic flow), and of mixed subsonic-supersonic flows. Part VII deals with an exposition of unsteady one-dimensional flows. Part VIII is an examination of the viscous and heat conduction effects in laminary and turbulent boundary layers, and of the interaction between shock waves and boundary layers. For those readers not already familiar with it, the mathematical theory of characteristic curves is briefly developed in Appendix A. Appendix B is a collection of tables which facilitate the numerical solution of problems.

Business, Legal and Ethical Phases of Engineering

D. T. CANFIELD *and* J. H. BOWMAN, *Professors of Electrical Engineering, Purdue University.* 6 x 9 *in.*, 365 *pp, Second Edition. Published by the McGraw-Hill Book Co., Inc.*, 330 *West* 42 *St., New York* 36, *N. Y.* $6.

The second edition of a successful work designed to help the engineering student make the transition from the classroom, where theory is predominant, to the field, where practical situations often have more than one definite answer. It also helps the student become aware of the managerial duties many mature engineers assume, as well as informing him about engineer contacts and relations.

Part I is called Business Economy and covers such points as: business organizations; stocks, bonds and notes; money, interest and discount; annuities and sinking funds; insurance, bond interest and amortization; depreciation, maintenance and replacement; and economic selection.

Part II, on Cost Determination, comprises: distribution factors; financial reports and records; allocation of burden or overhead; and public utility rates.

Part III is devoted to Business Law and discusses: law and the courts; contracts of commerce; competent parties; offer and acceptance; reality of con-

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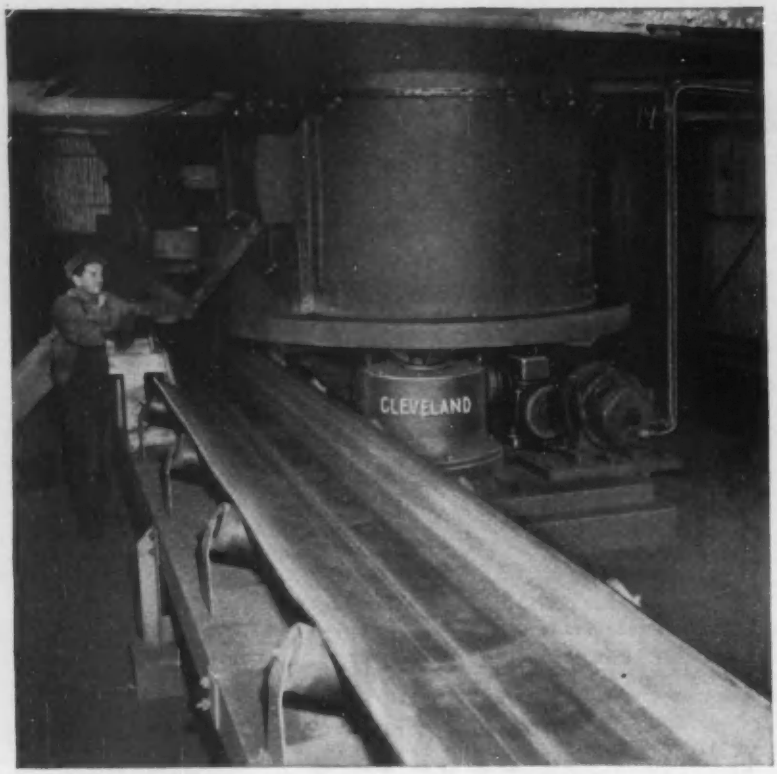

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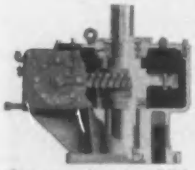

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sent; consideration; lawful subject matter; statute of frauds; discharge; agency; negotiable instruments; sales and sales agreements.

The final section covers Engineering Procedures, and discusses: engineering bids and specifications; patents, copyrights and trade-marks; insurance, industrial hazards, and employment compensation; the practice of engineering; and engineering as a profession.

This text contains material that might be covered in a course in engineering economics, and an effort has been made to generalize all examples and problems, even to the point of possible sacrifice of the individual student's interest in his own particular brand of engineering.

Designing by Photoelasticity

R. B. HEYWOOD, *Principal Scientific Officer, Structures Dept., Royal Aircraft Establishment, Farnborough, Hants., England; formerly in Research Lab., Rolls Royce, Ltd., Derby.* 414 *pp.*, 5½ x 8½ *in. Published by Chapman & Hall, Ltd.*, 37 *Essex St., W. C.* 2, *England.* $9.10.

This book is intended for designers and photoelasticians. Design has undergone a gradual evolution in the last few decades, and in mechanisms and machinery in general something more than a knowledge of nominal stresses is required. This is the geometry or form of the part considered in relation to the local maximum stresses—"stress concentrations"—that it produces. In many cases the magnitude of these local stresses is the all-important factor determining strength.

The subject of stress concentrations has grown simultaneously with the importance of fatigue as a cause of failure of parts. Fatigue is receiving prominence because of the greater degree of mechanization and the need for economy in weight, and the designer is accordingly forced to design for fatigue instead of for static strength. This implies that the magnitude of stress concentrations must be assessed in order to obtain an efficient design.

The assessment of stress concentrations normally presents considerable difficulty, owing to the advanced knowledge in mathematical or experimental methods required. It is one

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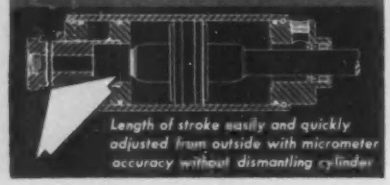

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purpose of this book to draw attention to the powerful photoelastic method of stress analysis and to point out recent simplifications that have been made in technique, so that routine checks on complicated designs become possible. Also, new photoelastic materials are available that tend to improve the accuracy of stress determination. The procedure requires an engineer familiar with the design aspect of the problem rather than a physicist highly skilled in photoelastic techniques.

Much is known about stress concentrations from papers scattered throughout the literature of the subject, and in Part 2 stress concentration factors potentially useful for direct application to design problems have been correlated and presented in graphical form for ease of reference.

It is realized that abrupt changes in shape of a part are often inevitable, and a chapter has been devoted to methods whereby stress concentrations can be lessened by suitable design, increasing strength without the penalty of increased weight.

In the last chapter it is pointed out that the interpretation of stress concentrations to strength values does not always agree precisely with observed results. A theory is presented that permits a correlation to be made, so that estimated strength values are in better agreement with those observed experimentally.

Finally, a fairly extensive list of references is given, classified in order of subject and chronologically, so that further information on any point may be obtained without difficulty.

Statics and Strength of Materials

ROLAND H. TRATHEN, *Prof. of Mech., Rensselaer Polytechnic Institute.* 6 x 9 *in.*, 506 *pp. Published by John Wiley & Sons,* 440 *Fourth Ave., New York* 16, *N. Y.* $7.50.

The author's objectives in this basic mechanics book were:

1. To present the principles of statics and strength of materials and indicate the general methods of applying them to engineering problems.
2. To develop analytical ability by setting the engineering application in such a way that it presents a challenge in analysis.
3. To correlate previous experiences in

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mathematics and physics with the discipline in mechanics.

4. To develop an appreciation of mechanics as a science.

The book differs from existing texts in that statics and strength of materials have been unified to form a first course for engineering students. The chapters are:

1. Some Fundamental Concepts
2. Bars Under Axial Loading
3. The Tress, Simple Connection
4. Statically Determinate Beams
5. Twisting of Circular Bars
6. Stress at A Point And Combined Stress
7. Strain at A Points, Stress-Strain Relationships
8. Theories of Failure For Members Subjected to Biaxial Stresses
9. Additional Methods for Determining Beam Deflection.
10. Statically Indeterminate Structures
11. Beams—Special Problems
12. Columns
13. Dynamic and Repeated Loads
14. Forces in Space

Pressed Metal Institute—Transcript of 1953 Annual Technical Meeting

8½ x 11 *in.*, 166 *pp. Published by The Pressed Metal Institute,* 2860 *East* 130*th St., Cleveland* 20, *Ohio.* $5.

This transcript of the Fourth Annual Spring Meeting of PMI included the following sessions:

1. Press Guarding—C. Glenwood Rose, Moderator. Discussion by W. J. Searjeant, Searjeant Metal Products, Inc.; E. U. Whitacre, The Positive Safety Mfg. Co., Frank Salisbury, Security Controls, Inc.; Steven V. Hart, Electronic Control Corp.; A. S. Kelley, National Safety Council.

2. Designing Safety into Dies—C. Glenwood Rose, Moderator. Discussion by J. I. Karash, Reliance Electric & Engineering Company.

3. The Right Press for the Right Job—Raymond Peterson, Moderator. Discussions by W. B. Saul, L & J Corp.; Norman Dunlap, Minster Machine Co.; M. D. Verson, Verson Allsteel Press Co.; Gordon Sommer, Clearing Machine Corp.; C. F. Sherman, Henry & Wright Div., Emhart Mfg. Co.; Raymond Peterson, Peterson Engrg. Co.

4. Drilling, Tapping and Counter-

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boring in the Stamping Plant—C. C. Caditz, Moderator, Northern Metal Products Co. Discussions by H. C. Hurtt and Waldo Russell, Cleveland Twist Drill Co.; O. E. Koehler, Greenfield Tap & Die Corp.; Harry Fussner, The National Acme Co.; G. M. Hines, Magna Corp.; A. V. Bodine, Bodine Corp.

5. Work Simplification—C. C. Caditz, Moderator. Discussion by Allan Mogensen, Work Simplification Conferences, Lake Placid, N. Y.

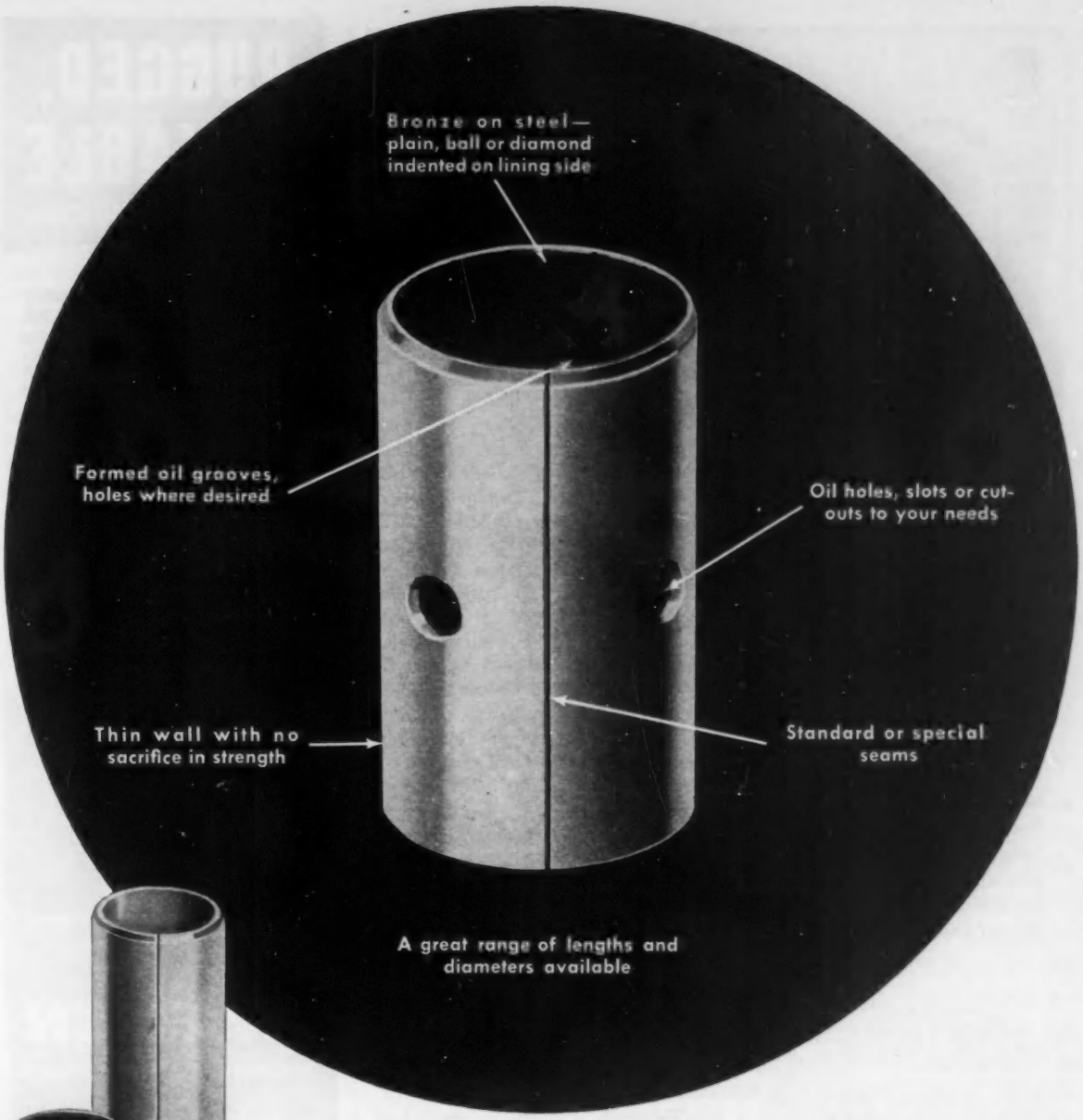
6. Die Breakage and How to Minimize It—J. W. Gulliksen, Moderator, Worcester Pressed Steel Co. Discussions by S. R. Cope., Acme School of Die Design Engineering, Inc.; F. B. Keser, Jr., Smith-Keser & Co.; Melvin Verson, Verson Allsteel Press Co.; W. P. Fouts, Dayton Rogers Co.; H. C. Johnson, Johnson-Chaflin Corp.

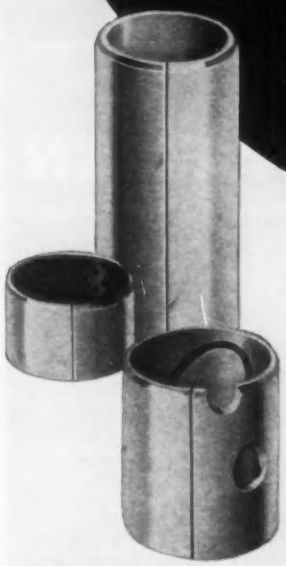
Stress Concentration—Design Factors

R. E. PETERSON, *Mgr. of Mechanics Dept., Westinghouse Electric Corp., Research Labs.* 9½ x 11¼ *in.*, 155 *pp. Published by John Wiley & Sons, Inc., 440 Fourth Ave., New York, N. Y.* $8.50.

This is a comprehensive collection of charts and design relations that are useful in making strength calculations for machine parts and structural elements. It should be regarded primarily as a working tool or handbook; it is not intended to be a textbook in the usual sense, and so only enough background and references are given to enable the reader to explore the subject further if he desires.

The contents include the following: List of Symbols; (1) Definitions and Design Relations, (a) Stress Concentration, (b) Strength Theory, (c) Notch Sensitivity, (d) Design Relations for Steady Stress, (e) Design Relations for Alternating Stress, (f) Design Relations for Combined Alternating and Steady Stresses, (g) Limited Number of Cycles of Alternating Stress; (2) Grooves and Notches, (a) Single Groove or Notch, (b) Multiple Notches, (c) Example (Shaft with Single Groove); (3) Shoulder Fillets, (a) Shoulder Fillet in Tension, (b) Shoulder Fillet in Bending, (c) Shoulder Fillet in Torsion, (d) Extrapolation Methods, (e) Relief Grooves, (f) Fillet of Non-Circular Contour;





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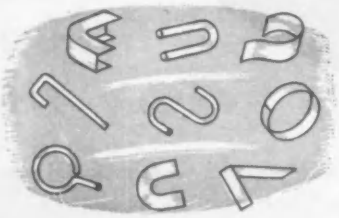

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A Handbook on Die Casting

Compiled by F. D. PENNY, *B. Sc. (Eng.) in collaboration with members of the Advisory Committee (Die Casting).* 6¼ x 9¾ *in.*, 78 *pp. Published by H. M. Stationery Office, London, England.* $1.40.

The book is primarily intended to assist the designers in British corporations in understanding the advantages and limitations of the die casting as to process, material, design and inspection.

By American standards, the book is exceptionally basic and of little value except for junior engineers who know little or nothing about die casting practice. Even then, care must be exercised, as British material specifications and methods are being described even though the materials are named.

Chapter I deals with general considerations: a definition of the two processes; the alloys that can be used; surface finish and dimensional accuracy that can be expected; advantages and limitations of the casting; and design

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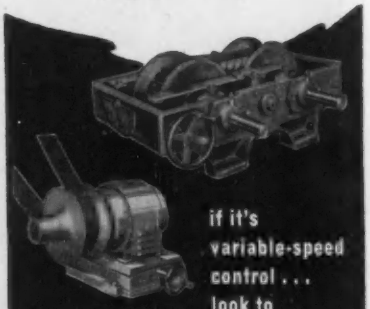

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principles. British designation for the processes are gravity die casting and pressure die casting. These are known in the U. S. as permanent mold casting and die casting respectively.

Chapter II describes the three die casting methods: air blown, hot chamber and cold chamber casting. Drawings show the general arrangement of the machines used and describe the process in fairly simple terms.

The next chapter concerns itself with casting dies. There are lengthy explanations on die cavities and parting lines; cores and slides; loose and collapsible cores; sprues, runners, gates and vents; ejectors; die temperature; and inserts. Several typical die drawings are shown, as well as several die cast parts.

Chapter IV is on permanent mold casting. A general description of the process is given, and the remainder of the chapter is concerned with the dies. Die coatings and temperature are discussed, as are die material and types of cores that can be used.

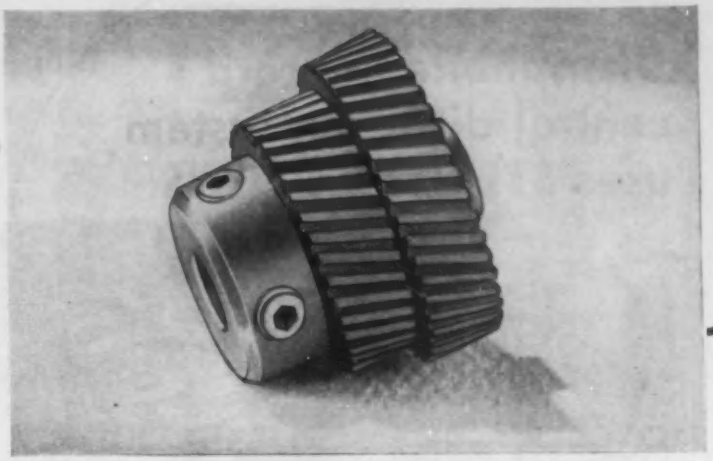
The remaining chapters of the book are of a general nature, dealing with die casting alloy, design of die castings and service inspection of castings.

The chapter on alloys is broken into four main headings, and the general characteristics of each group are referred to with a description of the physical properties of a number of alloys in each group. Chemical composition, physical properties, mechanical properties, corrosion resistance and available surface finishes of each alloy are listed in tables following the last chapter. The main material headings are: zinc, aluminum, magnesium and copper.

The design chapter is typical of any similar chapter. Design features are shown and discussed, and methods of changing designs to ease manufacture are illustrated. However, the subject is complex and it would take a complete book, rather than merely a chapter to cover the subject more than superficially. A single chapter of fourteen pages only scratches the surface.

The last chapter is a short description of inspection methods and what should be looked for. Again, no more than a superficial treatment of a rather complex subject is offered.

Several tables are included in the back of the book, as well as an appendix on "Inter-Service Specification for Zinc Alloy Pressure Die Castings."



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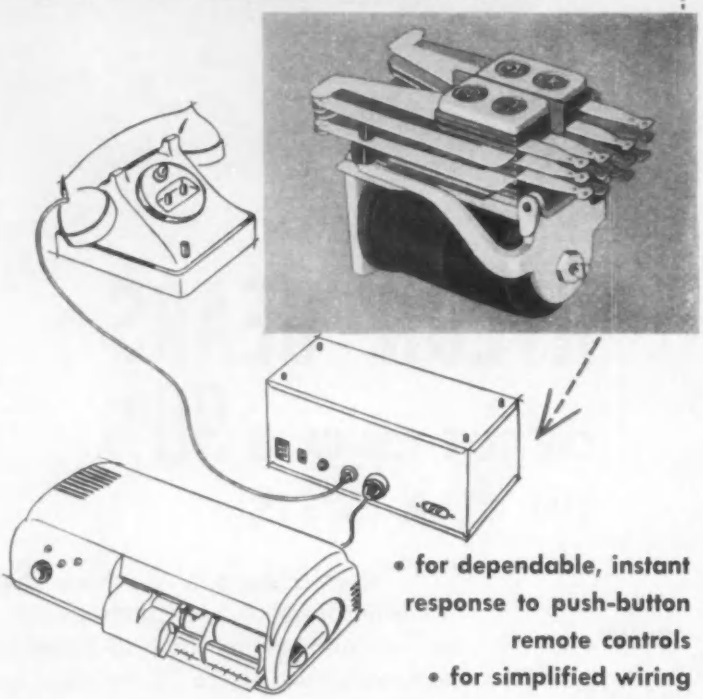

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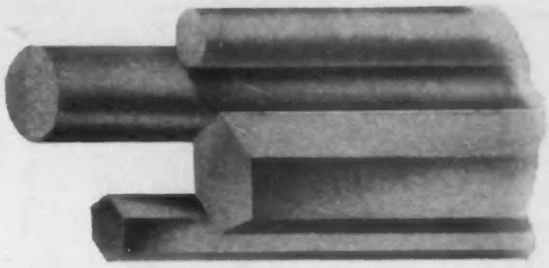

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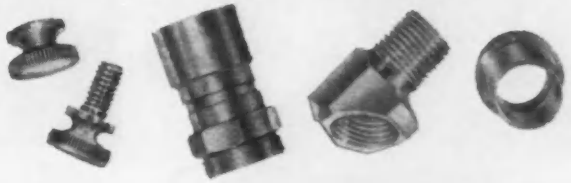
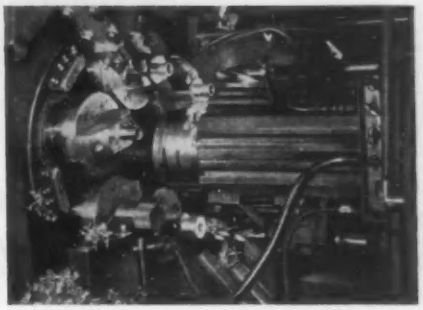


and faster production



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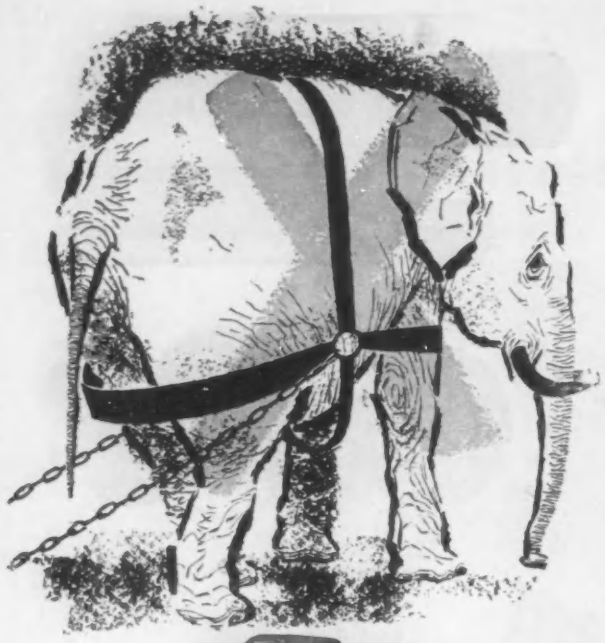

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. . . an efficient, all-purpose seal with long life and a wide range of applications

EXHAUSTIVE FIELD TESTS and customer usage show that the new Type LPD Clipper Seal has a wider range of applications than any other oil seal design.

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The heel and lip compounds in which the new Type LPD Clipper Seal is available enable it to withstand a wide range of service conditions and temperatures. For more information about the new Type LPD Clipper Seal, write Johns-Manville, Box 60, New York 16, N. Y.

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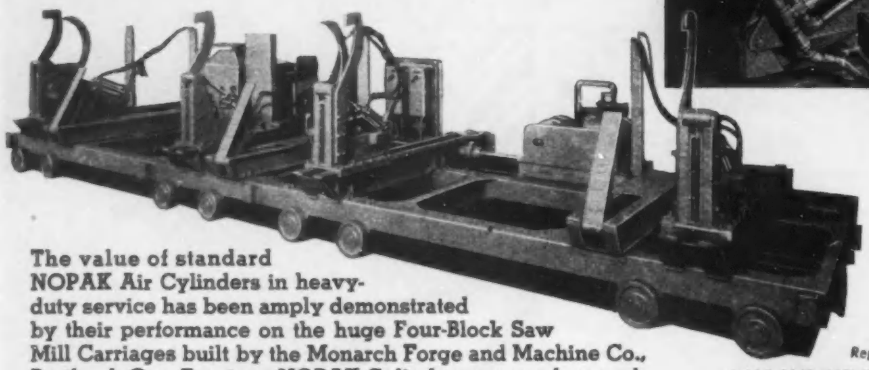
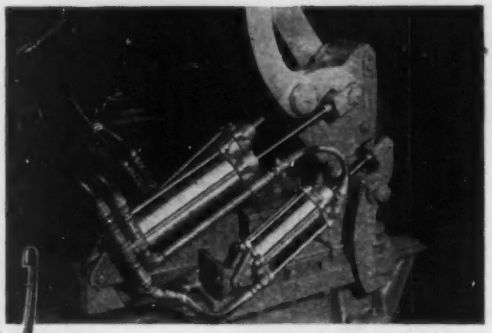
"Double Hook Dogs"

are Powered by NOPAK Cylinders on Monarch Four-Block Saw Mill Carriages





Close-up view of "Double Hook Dog" assembly shows how 3 NOPAK Model "E" Cylinders of different diameters and stroke lengths are employed to operate this mechanism. There are 4 of these "Double Hook Dogs" on each carriage.

Refer to Sweet's File for Product Designers or write for Bulletin SW-2.

The value of standard NOPAK Air Cylinders in heavy-duty service has been amply demonstrated by their performance on the huge Four-Block Saw Mill Carriages built by the Monarch Forge and Machine Co., Portland, Ore. Fourteen NOPAK Cylinders are used on each of these carriages which are extremely rugged in construction, and designed especially for the large western mills which utilize old growth fir and redwood logs. Monarch continues to specify NOPAK Cylinders because they really stand up under the rugged operating conditions to which they are subjected day after day, throughout the year.

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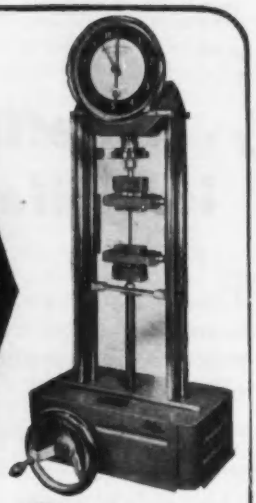

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Bodine offers you a wide variety of standard motors . . . over 3500 in all types and ratings (1/2000 to 1/6 HP) . . . and nearly a half century of experience devoted exclusively to the manufacture of quality fractional horsepower motors. For sound motor counsel, call on Bodine, today.

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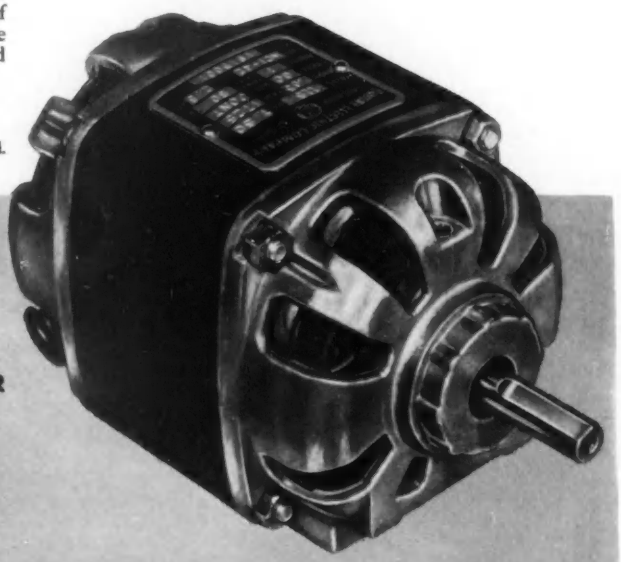
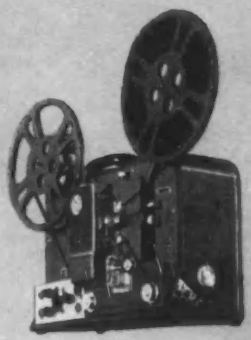
Is constant motor speed plus low external field a tough design problem?



Movie Sound 8

MOVIE SOUND 8 RECORDER-PROJECTOR

The new Calvin Movie Sound 8 Recorder-Projector is designed to permit you to add sound to your new or old 8mm film. You simple have a magnetic stripe applied to your film and then record with the Movie Sound 8. A reliable Bodine 1/40 HP motor provides the drive for this new product.



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BODINE MOTORS

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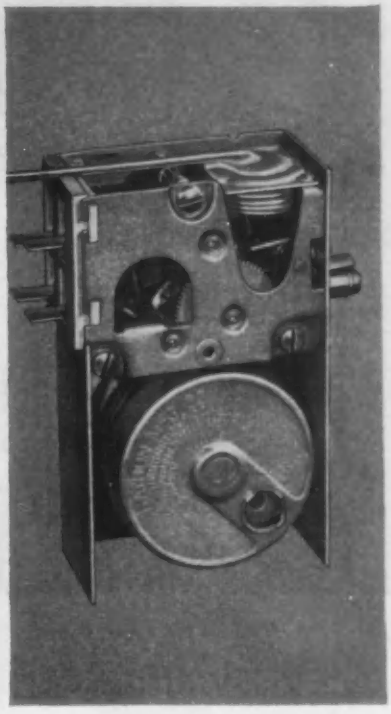

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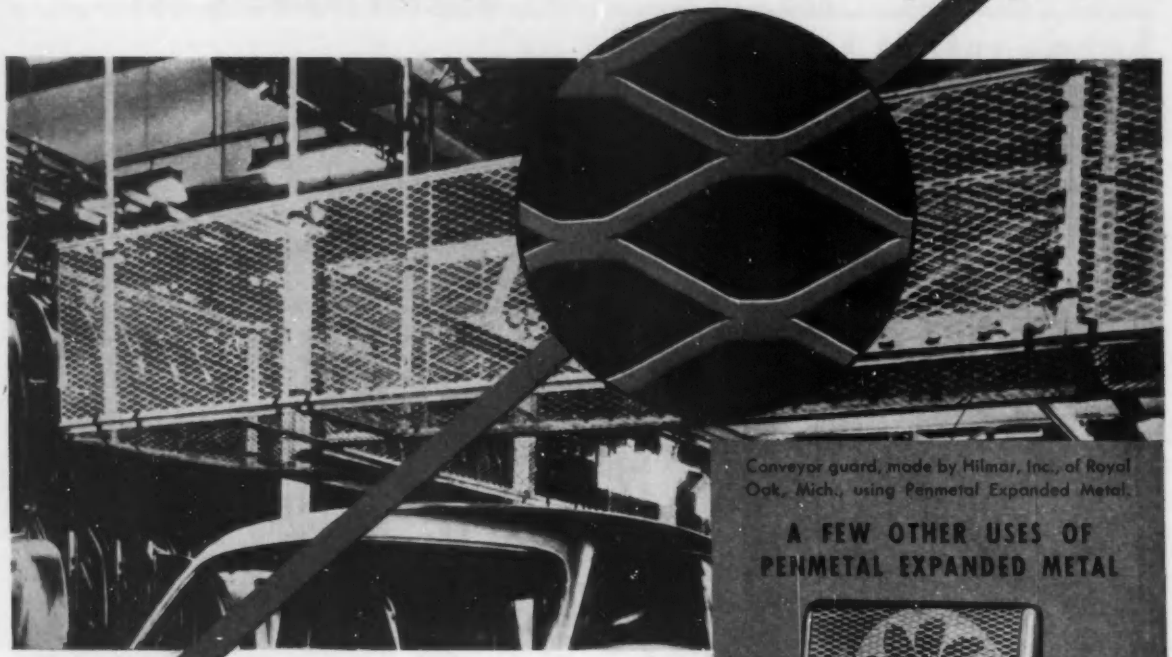

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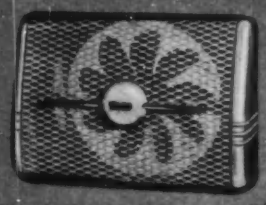

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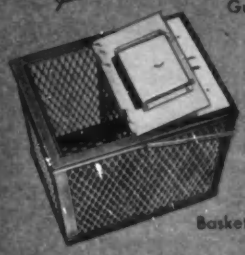
Heater Guards



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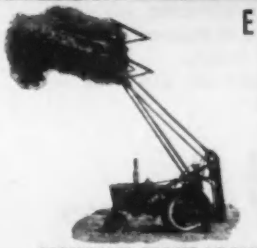

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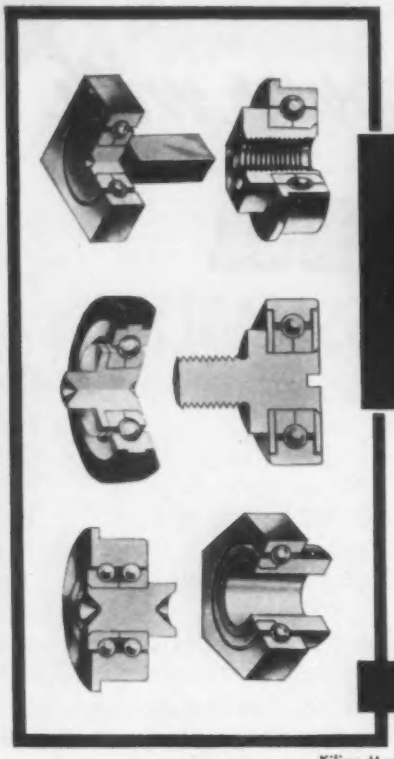

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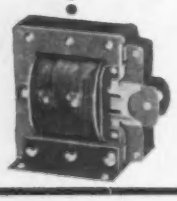

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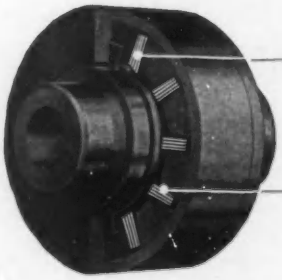

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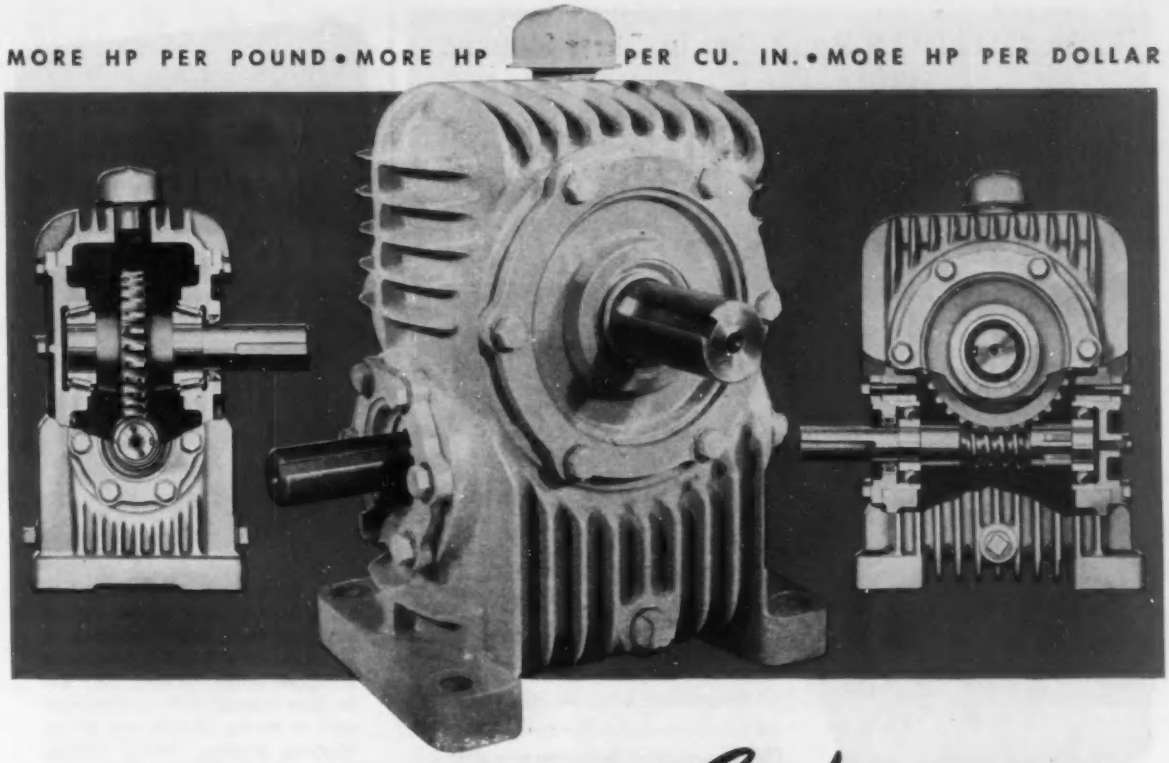

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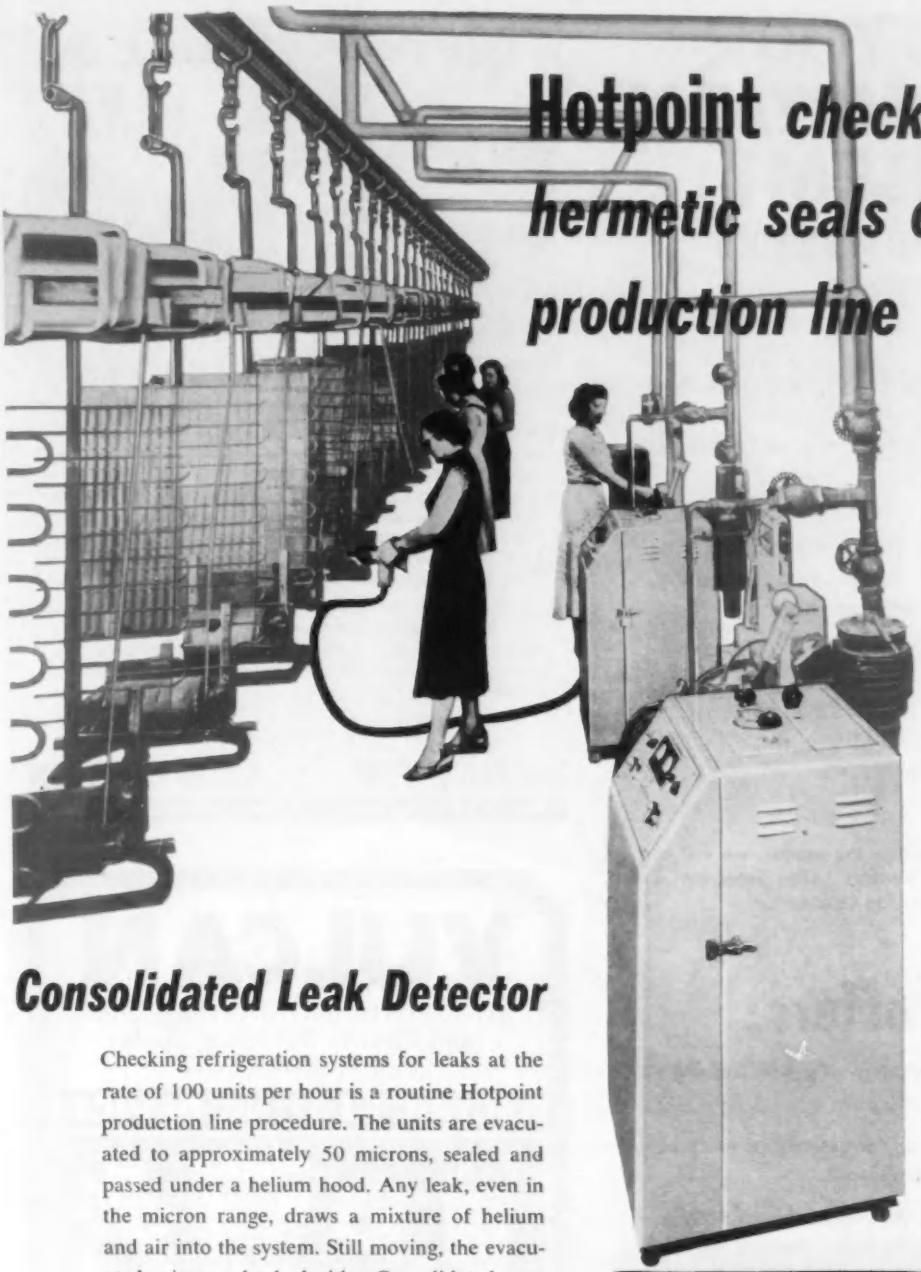

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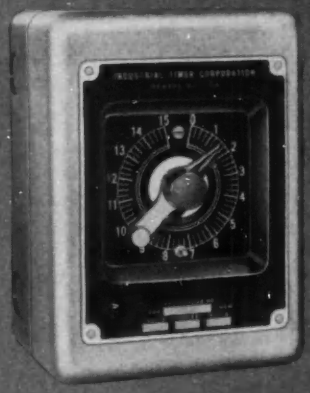

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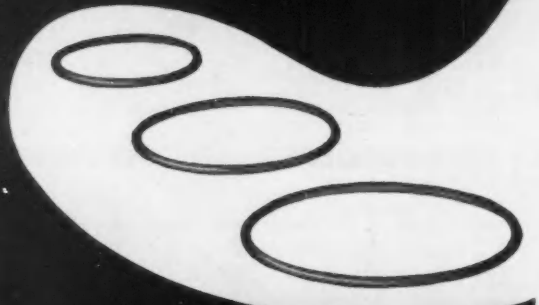

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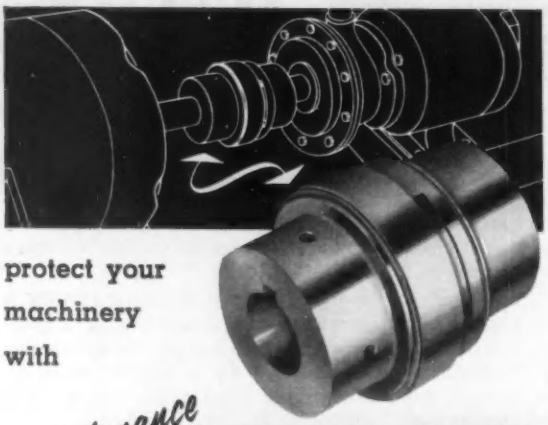

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DESIGNING WITH ALUMINUM

NO. 6

This is one of a series of information sheets which discuss the properties of aluminum and its alloys with relation to design. Extra or missing copies of the series will be supplied on request. Address: Advertising Department, Kaiser Aluminum & Chemical Sales, Inc., 1924 Broadway, Oakland 12, California.

THERMAL TREATMENTS

PROPER USE OF ANNEALING AND HEAT TREATMENT WIDENS SCOPE OF APPLICATION, DESIGN AND FABRICATION WITH ALUMINUM ALLOYS

FAMILIARITY with the thermal treatments which apply to aluminum and with their influence on metal behavior is frequently as important in design and alloy selection as in fabrication. This is especially the case in dealing with the wrought alloys, where forming of some sort is a regular concern; with the cast alloys the problems customarily revolve around such requirements as castability, machinability and strength, but not forming.

The major thermal treatments are annealing, and the solution and precipitation heat treatments which are often referred to singly or together under the general, but loose term "heat treatment." Their intelligent consideration in design and manufacture makes it possible in many cases to derive maximum advantage of aluminum's combination of desirable properties such as light weight with strength, corrosion resistance, conductivity, reflectivity and appearance.

The metallurgical aspects of the thermal treatments are quite complex, but it is possible to discuss their processes and effects satisfactorily in a general way insofar as they affect design problems.

Annealing Only Way To Remove Hardening

Annealing is a treatment to soften the metal and render it more ductile and susceptible to forming operations. It applies to both the non-heat-treatable and heat-treatable alloys although there is some difference in how the annealing treatment accomplishes its purpose.

Because cold working produces progressive hardening, it is frequently necessary in fabrication to anneal non-heat-treatable material after one or more sets of fabricating operations in order to proceed with further forming. With most of the group of alloys, annealing is carried out by raising the metal to a temperature of about 650°F although a higher temperature, 760°F, is required for the manganese-type alloy 3S that is so generally used for many formed articles. Normal air cooling to room temperature follows.

During the annealing process the grains which have been deformed by cold working are recrystallized into new ones that are equiaxed, and the metal reaches a stable condition in which there is no strain. It is important that the material be brought to temperature as rapidly as possible and that it be exposed to heat only long enough to bring the entire part to temperature. Slow heating rates and overlong heating tend to create larger grains in the annealed metal, a structure that is usually undesirable.

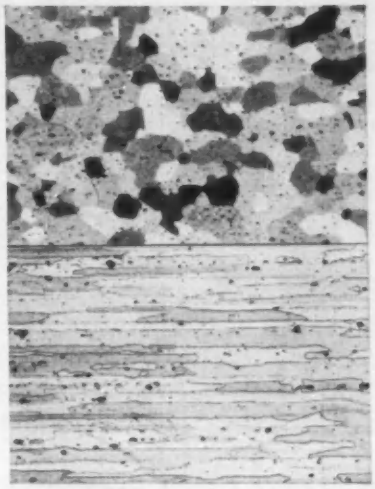


Fig. 1—TYPICAL GRAIN STRUCTURES
Photomicrographs show grain structures typical of non-heat and heat-treatable wrought alloys. Top: 50S-0 (anodic etch); bottom: 75S-T6 (phosphoric-Keller's etch).

When annealed, metal which has had only a small degree of cold work also tends to form larger grains than that which has been work-hardened considerably. With the non-heat-treatable alloys, of course, strength and hardness can be increased again, after annealing, only by further cold working. Therefore, where annealing is required at some intermediate stage in fabrication, careful consideration should be given to its exact location.

Cooling Rate Critical For Heat-Treatable Alloys

Annealing of the heat-treatable alloys removes the effects not only of any cold working the material has undergone but also of previous heat treatment, so that practice differs from that followed with the non-heat-treatable alloys. Precipitated particles of alloying elements must be coalesced, which reduces them in number and enlarges them in size, thus nullifying their hardening effect.

Higher temperatures, ranging between 750°F and 800°F, are therefore required, and the rate of cooling becomes of critical importance. It must be slow, no more than 50° per hour down to temperatures of at least 500°F, so that constituents taken into solid solution are precipitated as relatively large particles and heat treating effects are avoided. As with the non-heat-treatable alloys, excessive temperature and time may cause undesirable grain growth.

The annealed tempers of the heat-treatable alloys are used for forming purposes. Aside from the fact that there would be no reason for using them in a finished item, several of this group of alloys have lower resistance to corrosion resistance in the annealed temper as compared with heat-treated material.

The fact that a large class of alloys acquires optimum properties through heat treatment is a strong factor in extending the versatility and applications of aluminum. These alloys are heat-treatable because some of the elements and compounds go into solution with aluminum at elevated temperatures, and then after appropriate treatment are precipitated out at lower temperatures. This action promotes a structure that resists internal crystal slip and so increases the strength and reduces the ductility of the material.

Heat-treatable alloys include those of the highest strength, ranging up to 83,000 psi tensile strength for 75S. In general, they fall into three types, depending upon the chief alloying elements: the magnesium-silicide, copper (including copper-magnesium) and zinc-magnesium groups.

PLEASE TURN TO NEXT PAGE ➡

TABLE 1 • TYPICAL HEAT TREATMENTS (1)

Alloy	Solution Heat Treatment (2)		Precipitation Heat Treatment		
	Metal Temp. °F	Resulting Temper (3)	Metal Temp. °F	Time, Hours	Resulting Temper (3)
11S	935-970	11S-T4	325	12-16	11S-T6
14S	930-950	14S-T4 (4)	335-345	8-12	14S-T6
17S	935-950	17S-T4 (4)			
18S	950-970	18S-T4	340	8-12	18S-T61
24S	910-930	24S-T4 (4)			
25S	955-970	25S-T4	340	8-12	25S-T6
32S	945-960	32S-T4	340	8-12	32S-T6
A51S	960-980	A51S-T4	340	8-12	A51S-T6
53S	960-980	53S-T4	340	8-12	53S-T6
61S	960-1000	61S-T4 (4)	325-340	10-16	61S-T6
75S	860-925	75S-W	245-255 or 210 followed by 310	22-26 4 4	75S-T6
195 (5)	960	195-T4	310	3-6	195-T6
356 (5)	1000	356-T4	310	3-5	356-T6

(1) Figures are given as a guide only; more details may be obtained for specific applications.

(2) Solution heat treatment times depend on the section thickness, varying from 10 minutes for thin sections up to several hours for thicker sections. Soaking should be followed by immediate quench; in cold water for light sections, in boiling water for heavier, thicker sections.

(3) Addition of cold work would change tempers —i.e., 11S-T3, 11S-T8, etc.

(4) After aging at room temperature for approximately four days.

(5) Casting alloys. Soaking time at solution temperature for average casting is 12 hours—hot water quench.

Heat Treatment Consists of Two Phases

Heat treatment to attain maximum strength consists of two phases: solution heat treatment and precipitation or aging, which may be natural or artificial (the latter being termed precipitation heat treatment).

In solution heat treatment, the metal is heated to temperatures ranging approximately from 900°F to 975°F (see Table 1). At that point certain of the alloying elements go into solution, or dissolve, in the solid metal. When the temperature is quickly lowered by quenching, the alloying elements remain in solid solution.

Immediately after quenching, the metal is quite soft. But it is not in a state of equilibrium because the material is in a supersaturated solution—the solid solubilities of these alloying elements in aluminum being less at room temperature than they are at solution heat treating temperatures.

Within a few minutes, however, the alloying constituents begin to precipitate as extremely fine particles in the solid metal and the strength begins to increase. There is considerable difference between alloys in the rate of this precipitation, or natural aging, as shown by Figures 2a and 2b. In 24S it progresses rapidly and uniformly at room temperature and is virtually completed at the end of four days, with maximum strength and hardness then obtained.

In 75S, natural aging proceeds at a much slower rate: there is practically no increase in strength during the first hour and it is actually many months before 75S will attain maximum strength. Therefore, in practice this alloy requires a low-temperature thermal treatment after solution heat treatment to have adequate precipitation for desirable strength. This is the artificial aging process called precipitation heat treatment.

FIG. 2a • RATES OF NATURAL AGING OF SOME HEAT-TREATABLE ALLOYS

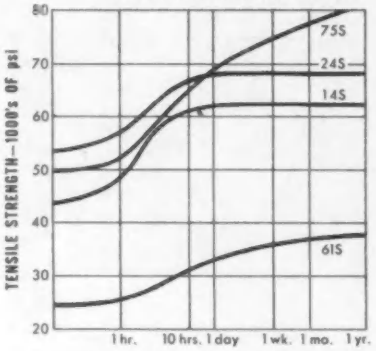
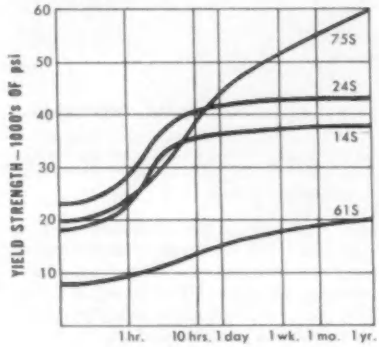


FIG. 2b



Another type of behavior is exhibited by 61S. It ages naturally at room temperature to one level of strength in four days, but can be given precipitation heat treatment (before or after natural aging) to T6 temper for maximum strength. It is quite common for a fabricator to obtain 61S material in the first condition (T4 temper) from the mill, do necessary forming and then achieve the full T6 properties by the relatively simple precipitation heat treatment.

Possibilities for Forming In Interim Condition

The behavior of the heat-treatable alloys as outlined above—especially the "delayed action" of varying duration between quenching and full precipitation—offers considerable opportunity in design and planning for forming operations.

For example, it is possible to solution heat treat and quench, do considerable forming while the metal is still relatively soft and then age the formed part either naturally or by precipitation heat treatment to maximum strength. This procedure can help avoid distortion problems likely to occur when forming the part entirely in the annealed temper and then heat treating, especially where light gauge material is being used.

Refrigerating material after quenching also slows down the rate of precipitation to such an extent that there is no increase in strength or hardness for an extended period of time. It is common practice to handle rivets made of heat-treatable metal in this manner, and the air-frame manufacturers have further developed the technique to a high degree for use in forming large parts and in bending large extrusions.

Other Thermal Treatments

Although they are of only minor interest to the designer, there are several other thermal treatments used with aluminum, such as stabilization and homogenization which are used in aluminum rolling mills and the treatment of some castings for stress relief and growth removal. Stabilization is a low-temperature treatment to establish the harder tempers of some of the magnesium-type non-heat-treatable alloys in a stable condition. Homogenizing consists of soaking the ingots of heat-treatable wrought alloys at elevated temperatures to distribute the alloying constituents uniformly before rolling.

More detailed assistance with design, alloy selection and fabrication and heat treatment procedure is obtainable through any of the Kaiser Aluminum sales offices located in principal cities. Or write to Kaiser Aluminum & Chemical Sales, Inc., 1924 Broadway, Oakland 12, California.

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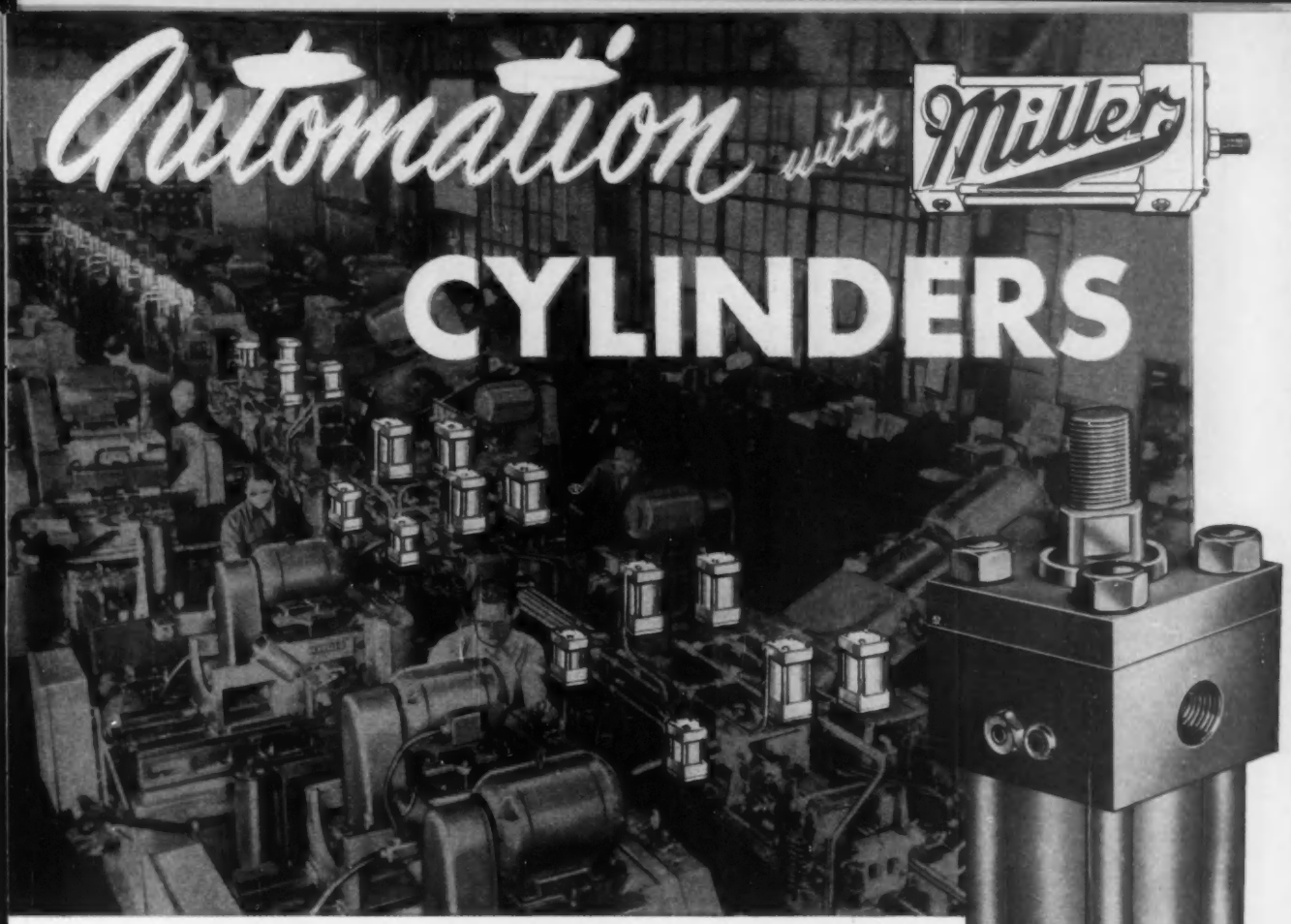

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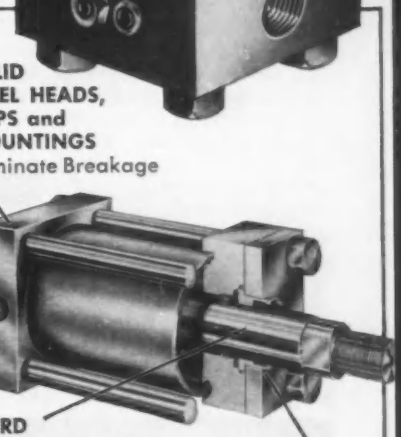

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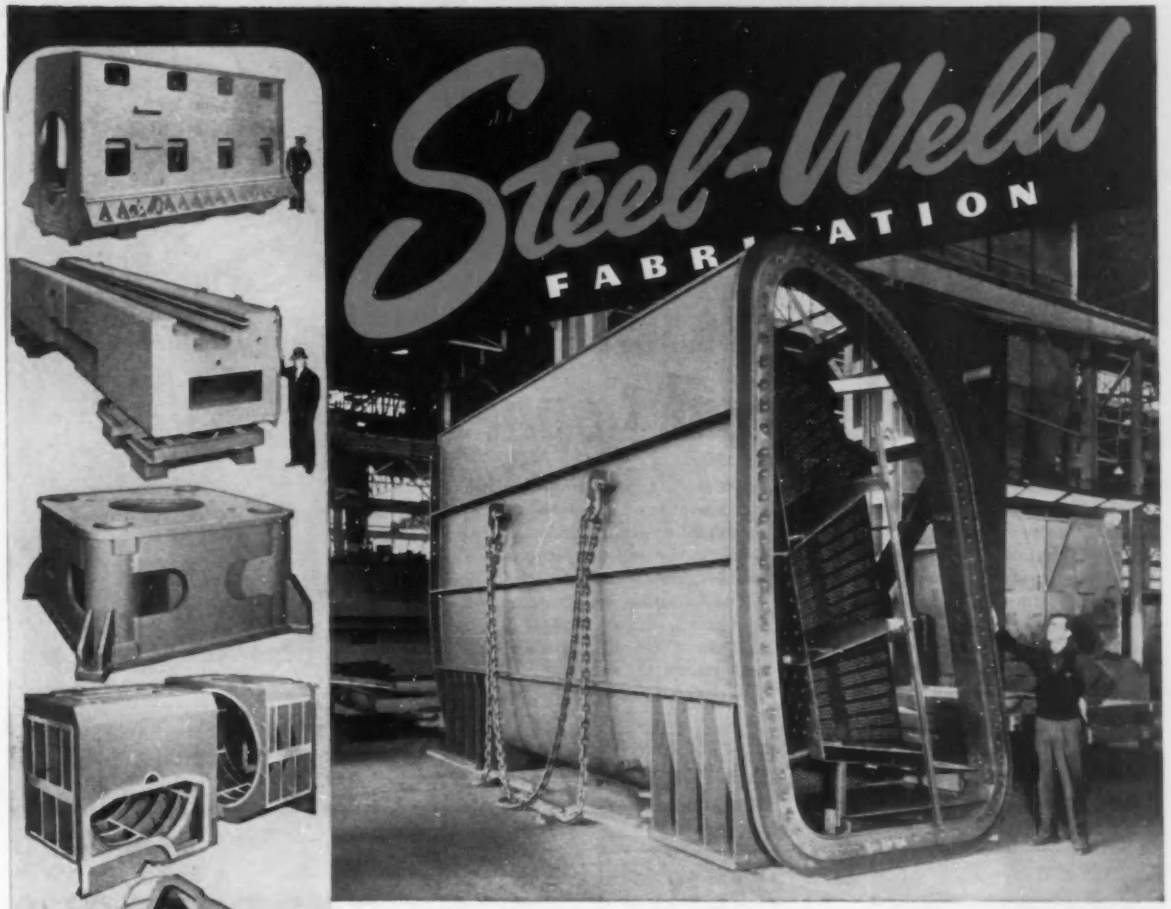

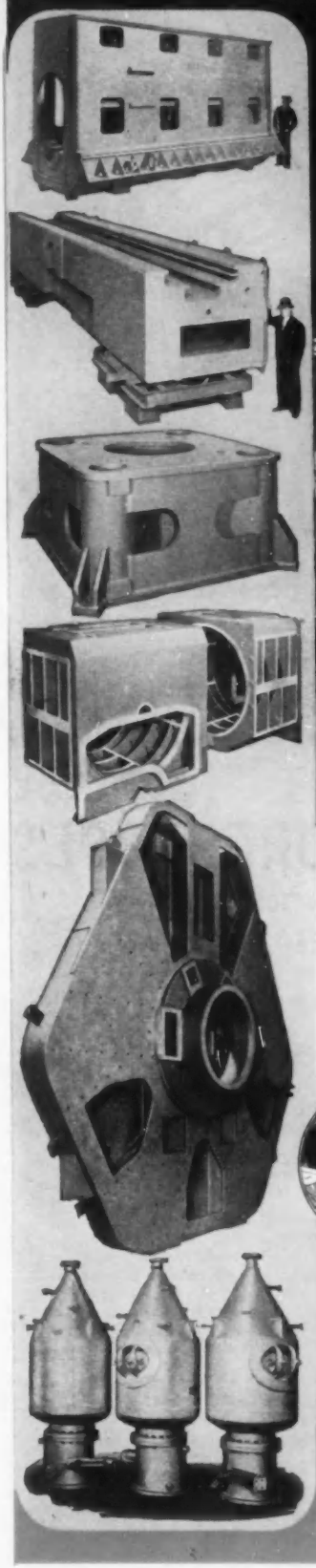

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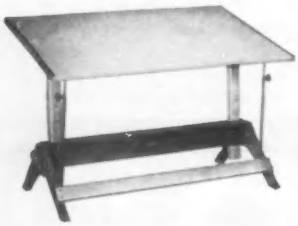

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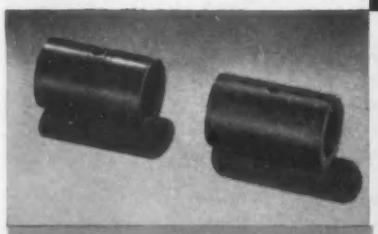

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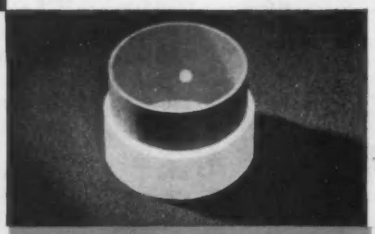

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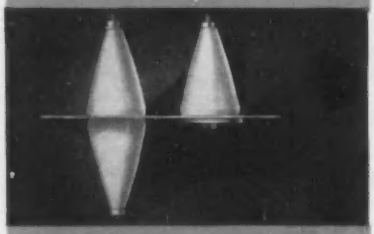

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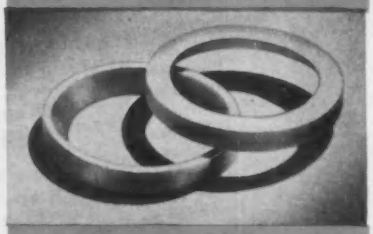

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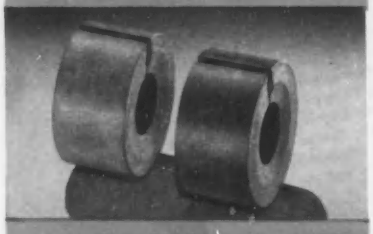

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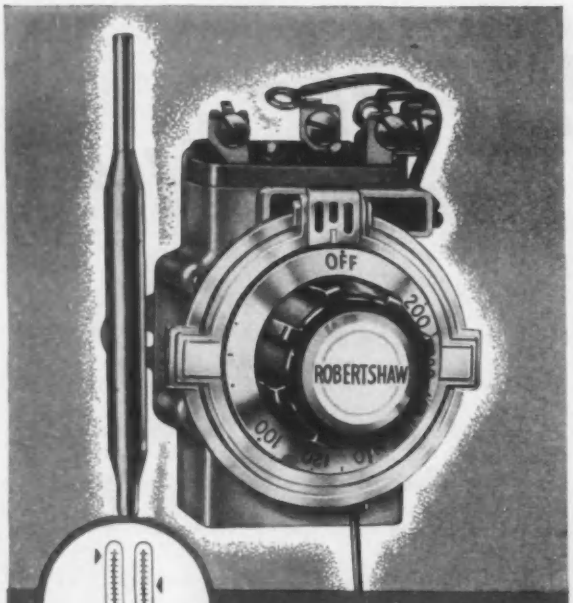

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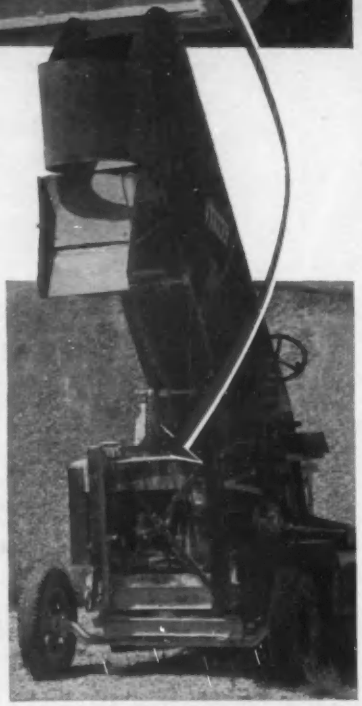

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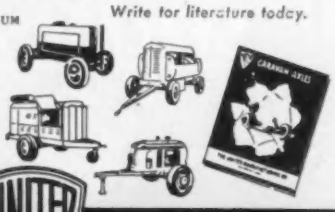

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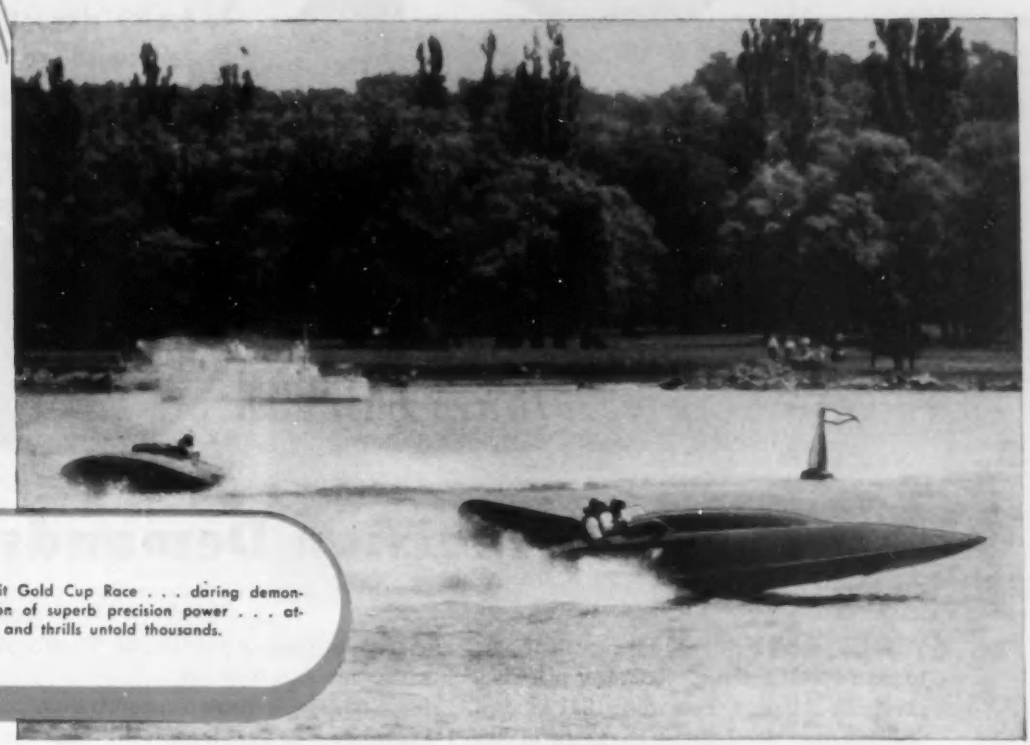

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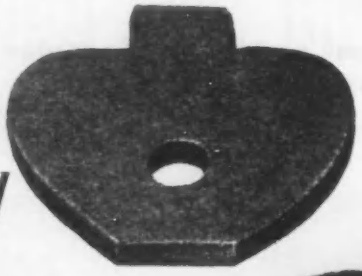

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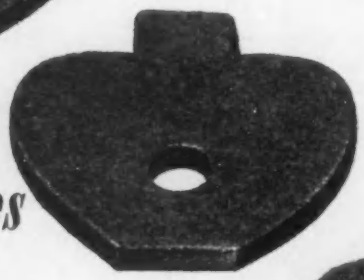

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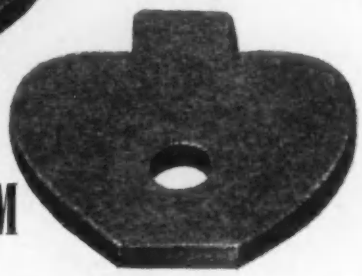

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DOW CORNING

Silicone News

No. 5 of a Series • PUBLISHED BY DOW CORNING CORPORATION, MIDLAND, MICHIGAN

New Data Reveals Effect of Heat Aging on Properties of High Temperature Laminates

Comparative studies of the effect of heat aging on light weight structural materials indicate that the better resin bonded glass laminates compare very favorably with light metals at high temperatures. These studies made recently by our engineers and summarized below in Table I show that the laminates have greater tensile strength than the metals at 500 F after aging for as little as half an hour at that temperature.

Tensile strength to weight ratio for the laminates is also superior to that of the metals under the same conditions. Measured at 500 F after 200 hours at that temperature, the tensile strength to weight ratio times 10^{-2} for the silicone-glass laminates is in the range of 4 to 5 times comparable values for the light metals.

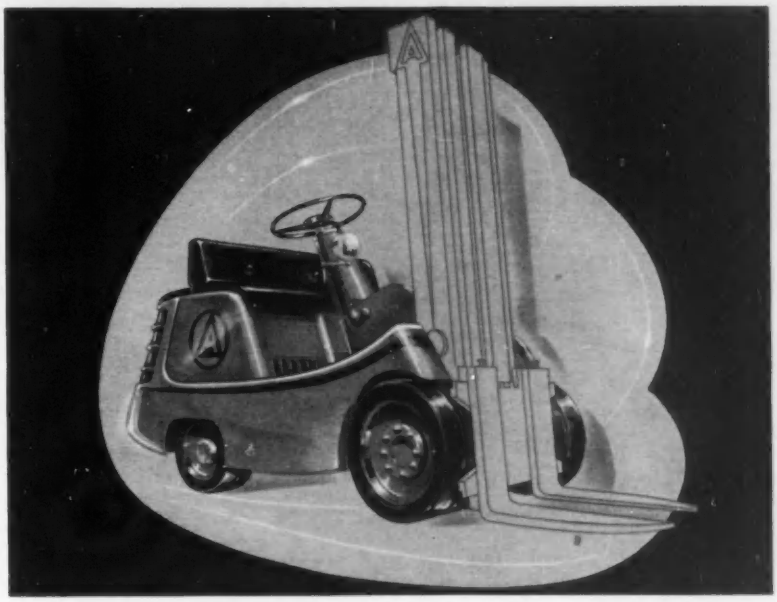
The organic resin bonded glass laminates show excellent short term retention of mechanical strength at 500 F. Strength falls off quite rapidly, however, with increasing time. The mechanical properties of the silicone-glass laminates at 500 F decrease during the first half hour and then improve or remain unchanged with increasing time. Weight loss, water absorption and dielectric properties of the silicone-glass laminates are markedly superior.

Included in this study were glass laminates bonded with several new, heat resistant low pressure phenolic, polyester and

(continued pg. 2)

TABLE I
EFFECT OF HEAT AGING ON HIGH TEMPERATURE LAMINATES AND LIGHT METALS

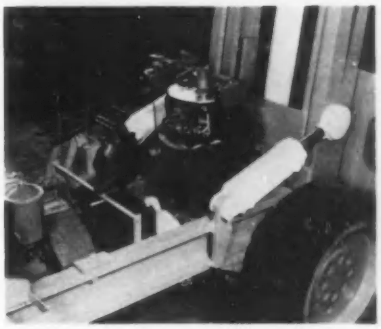
Property	High Pressure Silicone	Low Pressure Silicone	Low Pressure Polyester	Low Pressure Phenolic	Aluminum	Magnesium
Flexural Strength, psi						
As received	45-47,000	27-32,000	45-55,000	44-66,000		
At 500 F after						
½ hr at 500 F	5,000	12-15,000	35,000	41-50,000		
200 hr at 500 F	19,000	12-15,000	11-25,000	9,000		
Tensile Strength, psi						
As received	26-32,000	35,000	33-36,000	22-27,000	50-65,000	39-42,000
At 500 F after						
½ hr at 500 F	8-10,000	22-25,000	30-33,000	24-29,000	7-13,000	8,000
200 hr at 500 F	18-20,000	20-22,000	9,200	11-15,000	5-9,500	6,000
Density, g/cc	1.65-1.80	1.70-1.85	1.65-1.85	1.50-1.80	2.7	1.76-1.80
Tensile Strength to Weight ratio x 10^{-2}						
½ hr at 500 F	5.3	13.6	18.0	16.1	3.7	3.5
200 hr at 500 F	11.0	12.2	5.3	7.9	2.7	3.3
Weight Loss, percent 200 hr at 500 F	0.35-1.31	0.1-0.2	9.00	11.2		
Water Absorption, percent (After aging 200 hr at 500 F)	0.21	1.0-1.3	2.00	9.00		
Dielectric Strength, v/m, ⅛" electrodes						
As molded	80-100	300	90	200		
Aged 250 hr at 500 F	80-100	80-100	70	60		
Power Factor, percent						
As received, at 10^{6} cps	0.14	0.22	1.2	2.7		
Dielectric Constant						
As received, at 10^{6} cps	3.90	4.13	4.00	4.31		
Arc Resistance, sec.						
As received	300	350	185	165		



Designers Use Class H Insulation to Sell More Electric Machines in Buyer's Market

Instead of viewing with alarm our entry into a more normal competitive economy, Automatic Transportation Company has prepared for it. They have developed a new product with many strong selling features, including more continuous operation with minimum maintenance cost.

"Dynamotive", Automatic's newest entry in the materials handling equipment market, has so many new features that it bears little resemblance to the lift truck of 5 or 10 years ago. The first gas-powered, electrically driven fork lift truck, it has an electrical system that assures long service life by making it impossible to reverse the direction of the truck while it is in motion.



Engine wear and fuel consumption are minimized by an electrical transmission with its inherent overdrive feature that

(continued pg. 2)

DOW CORNING Silicone News

NEW DEVELOPMENT AND TECHNICAL DATA

For copies of any of the publications reviewed in this column or for data relating to any of the articles printed in this issue of the Dow Corning Silicone News, simply circle the corresponding reference number on the coupon below.

Silicones have captured the interest of imaginative designers. And it's not all idle thinking because the properties of these unique materials enable engineers to effect their ideas in new products and applications. A reprint of a recent BUSINESS WEEK article reviews some of the existing uses for silicones and forecasts many new silicone products for the industrial and consumer markets. *No. 44*

●

The use of bare magnet wire insulated with Dow Corning Wire Enamel makes possible longer life, increased reliability and reduction in size and weight of electronic devices, fractional and miniature motors. Accelerated tests at temperatures in the range of 200 to 275 C indicate its long term serviceability at temperatures up to 190 C (374 F.) A list of electrical wire manufacturers, who make such wire available in various sizes, is yours for the asking. *No. 45*

●

New source of supply list names more than 60 formulators supplying durable protective coatings made with silicone vehicles. Available coatings include white and colored silicone appliance enamels that withstand temperatures up to 700 F; aluminum pigmented finishes which minimize maintenance of exhaust stacks exposed to corrosive atmospheres and temperatures up to 1000 F; and modified silicone-organic paints that offer increased stability, greater resistance to temperature extremes, weathering, oils and greases. *No. 46*

●

The 1954 Reference Guide to Dow Corning Silicone Products summarizes properties and briefly describes applications for commercially available silicones including several new products. Containing a wealth of useful information about silicone products, the Guide belongs in every designing and engineering reference file. *No. 47*

●

Reprint of a recent article "Silicones In Packaging" describes how various silicones are used to advantage in handling, processing and packaging drugs and pharmaceuticals, baked goods, foods and beverages. *No. 48*

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New Silicone Coating Prevents Adhesion and Build-up on Rolls, Slashers and Drying Cans

A recently developed silicone product called Dow Corning XF-121, is proving to be a highly effective and economical coating for rolls, slashers, and drying cans used in the textile industry.

Properly applied, Dow Corning XF-121 forms a tough, resilient film which reduces the adhesion and minimizes build-up of such warp or sizing materials as starch, gelatin, synthetic rubber latices and styrenated resins. On high production units, only thin coatings are required to reduce scrap due to build-up, and to substantially reduce down time and maintenance costs.

Dow Corning XF-121 can be applied without dismantling equipment. Cost is only about 1% of the cost of the only other coating now available that gives comparable performance. In most applications, less than 4 pounds of Dow Corning XF-121 will cover 100 square feet of roll area. Reports indicate that even such thin coatings provide several weeks or months of service, depending on operating conditions. Production increases up to 50% have also been reported.

Supplied as a solvent solution with a 25% silicone content, Dow Corning XF-121 can be applied as received, or it can be thinned with additional solvent and applied by brush or spray. Properly catalyzed, it will air dry and cure overnight or it may be cured by heating for 1/2 to 1 hour at 200 F. The film is easily removed with a wide spatula or putty knife. *No. 41*

DESIGNERS USE CLASS H *(continued)*

automatically adjusts engine speed to load requirements. The engine and motor always run at the most efficient speed.

And to obtain still longer, more dependable service life, the generator and motor of the "Dynamotive", like all Automatic motors built since 1946, are protected with Class H insulation made with Dow Corning silicones. Automatic Transportation engineers report that: *"silicone insulation is used because it contributes to longer life and can take more abuse than other insulating materials. Since we adopted it over 7 years ago we have never, to our knowledge, lost a motor due to insulation failure."*

That's the kind of performance that has sold more and more electrical equipment manufacturers and their customers on the value of silicone (Class H) insulation They know from experience that Class H can be used to increase the power per pound ratio in electric machines by at least 50% without loss of efficiency. And, even more important in a buyer's market, they know that Class H outlasts ordinary insulation 10 to 1. *No. 42*

EFFECT OF HEAT AGING *(continued)*

silicone resins. The high pressure, silicone-glass laminate specified under NEMA Grade G-7 (LPI-1951) and MIL-P-997B was selected as a standard of comparison.

Style 181 glass cloth, heat treated for the silicone resins and Garan finished for the organics, was used for all laminates. Test samples were cut from 1/8" sheets which had been cured according to the resin manufacturers' recommendations.

High pressure silicone-glass laminates were press cured at 350 F followed by a graduated cure in an oven at temperatures ranging from 194 to 392 F for a total of 24 hours. The low pressure silicone-glass laminates were aftercured for 150 hours at 482 F.

The tests included in this study were conducted according to Fed. Spec. L-P-406b. Flexural and tensile strengths were measured at test temperatures. Water absorption, dielectric strength and weight loss were measured at room temperature after aging for 200 hours at 500 F. Arc resistance, power factor and dielectric constant were measured at room temperature after curing. *No. 43*

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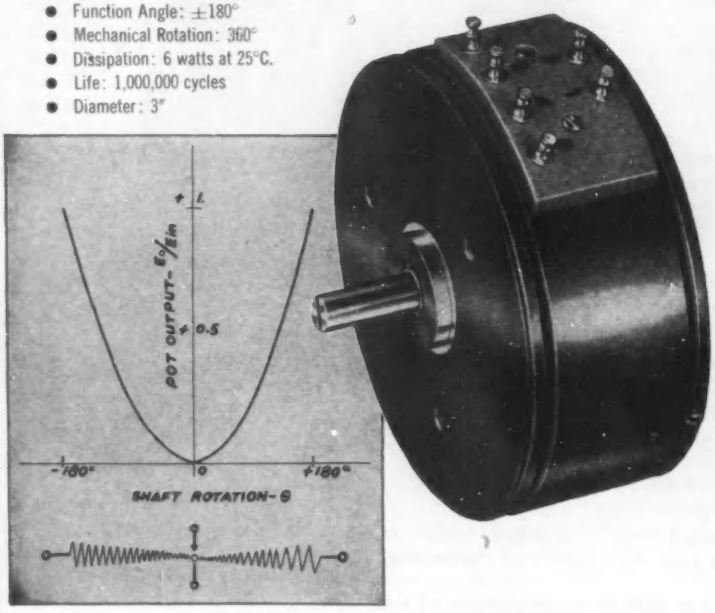

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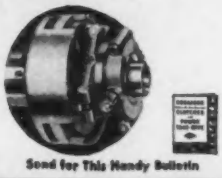

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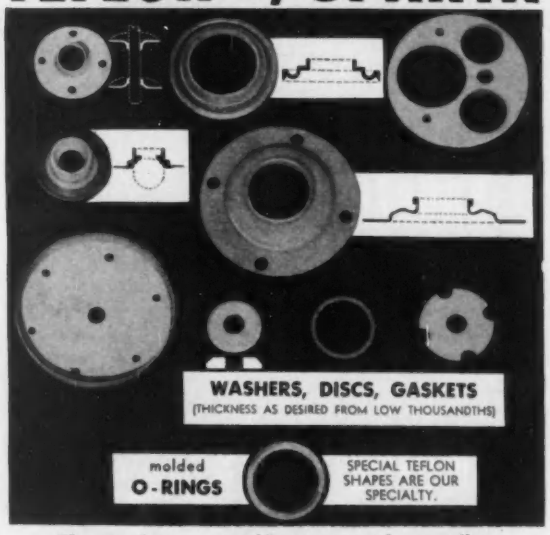

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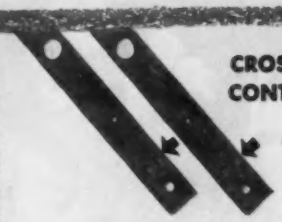

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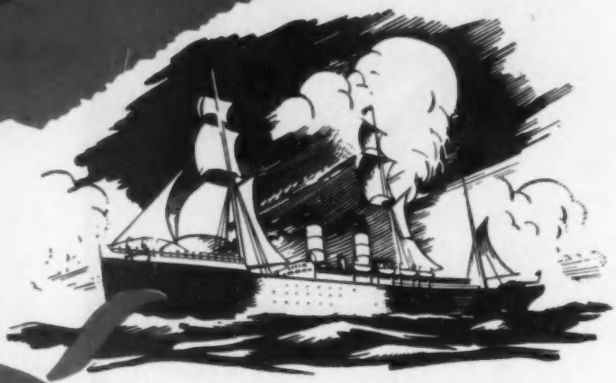

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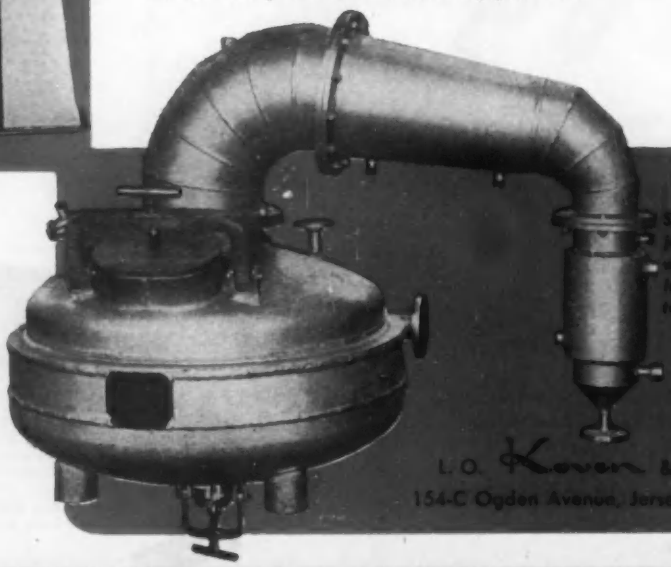

Stainless steel jacketed still with downpipe, inside polished to a sanitary finish

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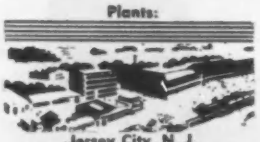

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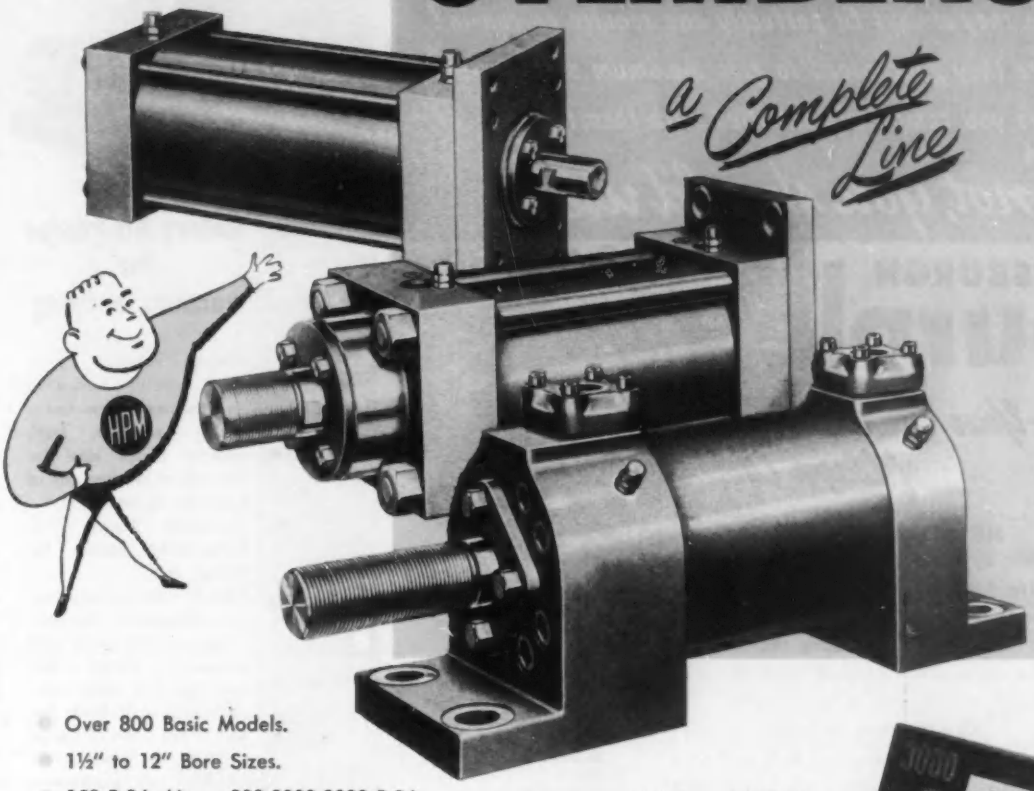
HPM HYDRAULIC POWER DIVISION

CYLINDERS

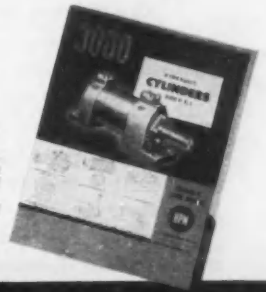
a Complete Line



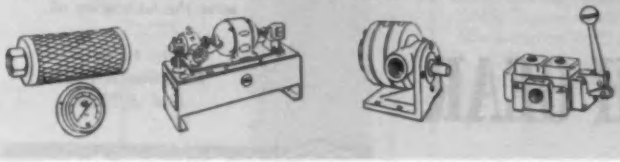
- Over 800 Basic Models.
- 1½" to 12" Bore Sizes.
- 150 P.S.I. Air, or 300-2000-3000 P.S.I. Oil Hydraulic Service.
- Large Choice of Mountings, Standard and Combinations.
- Male or Female, standard or 2:1, single or double end piston rods.
- Adjustable stroke models.
- Single acting, collapsible or telescopic, large bore and other special cylinders to meet unusual requirements.

Ask for new H-P-M Catalogs covering cylinders best suited to your requirements.

Cat. #701—150 P.S.I. Air, 300 P.S.I. Oil Cylinders
Cat. #721—2000 P.S.I. Oil Cylinders
Cat. #741—3000 P.S.I. Oil Cylinders



ACCESSORIES POWER UNITS PUMPS & MOTORS VALVES



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THE HYDRAULIC PRESS MFG. CO.
MOUNT GILEAD, OHIO, U. S. A.

2802 Marion Road

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Can You Check YES to these five questions?

- ☐ Do the gears you use have surface-hardened teeth?
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- ☐ Do they always fit perfectly and require no run-in?
- ☐ Are they guaranteed to give maximum service life?
- ☐ Are you completely satisfied with them?

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purple

—Your Guarantee of Longer Life

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ARMORED GEARS are made only by PITTSBURGH GEAR from an exclusive formula perfected by PITTSBURGH engineers. It covers metal, machining, and a method of heat-treating that hardens the wearing surfaces but leaves the core tough, ductile, and shock-resistant.

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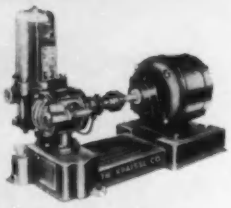

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Kraissl's patented, automatic, force-free lubrication and flushing system makes these direct-drive, high-capacity pumps ideal for the special requirements of bottle-filling machinery.

Air-cooled design — or water-cooled models for heavier duty.

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EXCLUSIVE CLASS 26 AIR FILTER

is available as an integral part of each pump up to 10 cfm — to produce oil-free discharge air and also conserve the lubricating oil.

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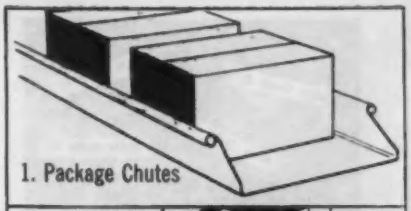
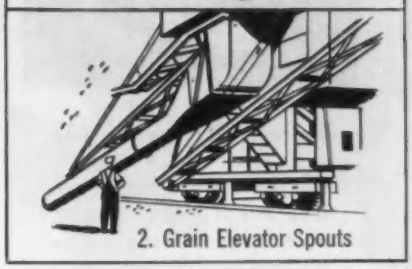


1. Package Chutes



2. Grain Elevator Spouts

USE HARD, SMOOTH, DURABLE

Porcelain Enamel

to combat

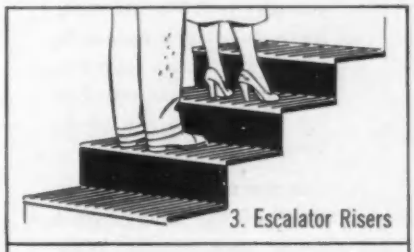
Abrasion

MEASURED by scratch test using Moh's scale, the hardness of Porcelain Enamel is between 5 and 6 for most grades. This compares to a Knoop hardness of about 360-560.

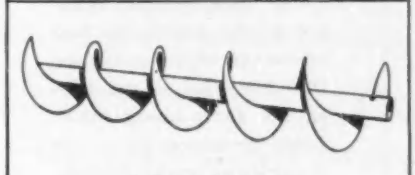
Measured by loss of gloss under standard abrasion conditions, Porcelain Enamels designed for abrasion resistance have a minimum index of 60, which may be compared with an index of 50 for good plate glass. Because Porcelain Enamel is one of the hardest substances known, it has great value as a material to resist abrasion.

Abrasive conditions frequently are accompanied by high temperatures, corrosive conditions, impact and heavy loading. The ability of Porcelain Enamel to meet these hazards makes this material valuable for a wide variety of applications, some of which are illustrated at the left. Its low coefficient of friction, high strength-weight ratio, low cost and chemical inertness are added advantages of Porcelain Enamel.

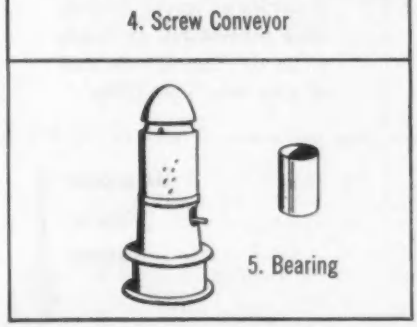
We will be glad to send you the new Porcelain Enamel Design Manual, containing suggestions for using this versatile material most advantageously.



3. Escalator Risers



4. Screw Conveyor



5. Bearing

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Weighs only 9 ounces.

TOP QUALITY

Finest materials—Engineered Construction.

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Performance measured in millions of cycles.

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Competitively priced.

There's "value-plus" in these new, miniature Skinner V2 Stainless Steel Valves. They are competitively priced, yet skillfully engineered to highest quality standards. Stainless steel internal parts, bubble-tight shut-off, and direct mounting make them ideal for a wide range of applications, such as automotive fuel systems, humidifiers, lubricating systems, welding and spraying equipment, and many others.

Skinner V2 valves feature "fail-proof" shut-off — pressure and springs combine to snap valves shut at the instant current goes off. Precision-molded HY-CAR plunger inserts assure leakproof operation — through millions of cycles. Moisture-resistant, varnish-impregnated coils and aircraft type O-ring seals are other quality features. *Write for BULLETIN 534*

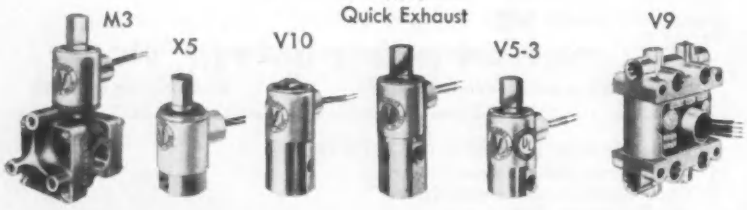
SPECIFICATIONS

Type	Two-way Normally Open or Normally Closed
Pressure Range	0-250 P.S.I.
Orifice Diameter	3/64" to 1/8"
Pipe Size	1/8" or 1/4" NPT
Voltage	All common AC, DC Voltages
Power Consumption	9 Watts Maximum

Skinner V2 Series Valves are also available with or without time delay for pressure type oil burner. *Write for BULLETIN 528*

TYPICAL SKINNER VALVES

Write for information about our complete line.



SKINNER ELECTRIC VALVES — SOLENOID VALVES

THE SKINNER CHUCK COMPANY

114 EDGEWOOD AVENUE, NEW BRITAIN, CONNECTICUT

But why MEN over 45?

Our doctors still don't know *why*, but if you are a man over 45 you are six times as likely to develop lung cancer as a man of your age twenty years ago. They *do* know, however, that their chances of saving your life could be about *ten times* greater if they could only detect cancer long before you yourself notice any symptom. (Only 1 in every 20 lung cancers is being cured today, largely because most cases progress too far before detected.)

That's why we urge that you make a habit of having your chest X-rayed every six months, no matter how well you may *feel*. The alarming increase of lung cancer in men over 45 more than justifies such precautions. Far too many men die *needlessly!*

Our new film "The Warning Shadow" will tell you what every man should know about lung cancer. To find where and when you can see this film, and to get life-saving facts about other forms of cancer, phone the American Cancer Society office nearest you or simply write to "Cancer"—in care of your local Post Office.

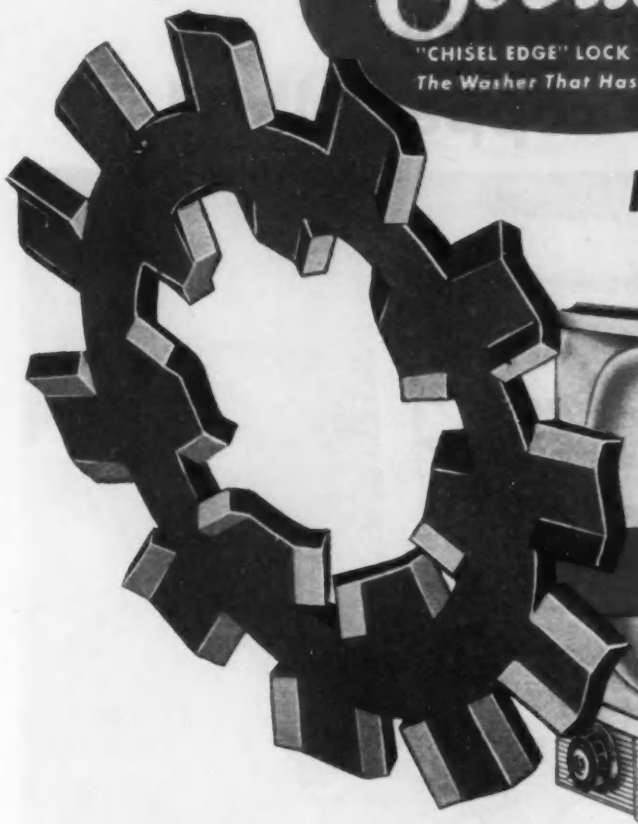
American Cancer Society

AMF

Everlock

"CHISEL EDGE" LOCK WASHERS

The Washer That Has The Edge



helps put the "LOCK" in Admiral's "locked-in stability"

Placed at strategic points in the chassis, Everlock lockwashers help keep Admiral TV sets at their brilliant best. Everlock's exclusive alternating chisel edges actually bite into both work and screw—provide fastenings that are *permanently secure.*

Remaining tight for the life of the product, Everlock lockwashers, locknuts and lock terminals help to safeguard many of America's foremost products.

If permanent, vibration-proof fastenings are part of *your* production picture, remember—with Everlock, you can *fasten* it and *forget* it. In sizes and materials to meet any specifications.

A full line of Everlock lockwashers and locknuts. Write for free catalog.

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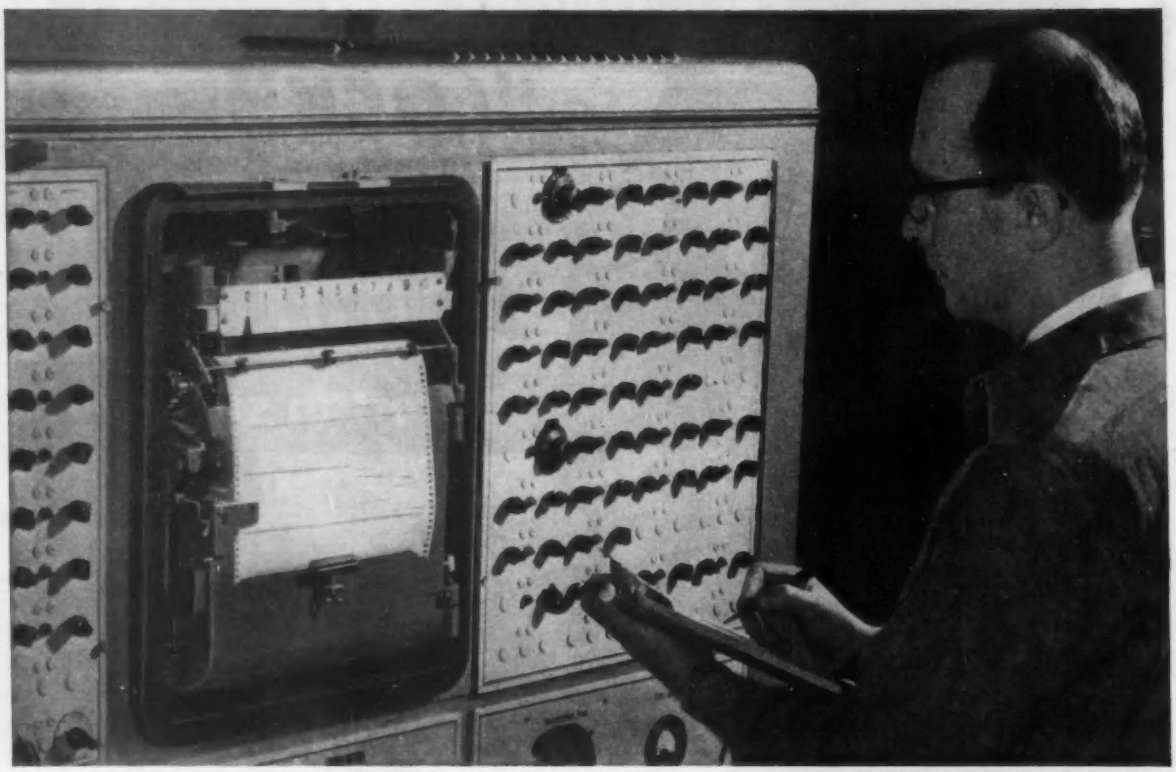
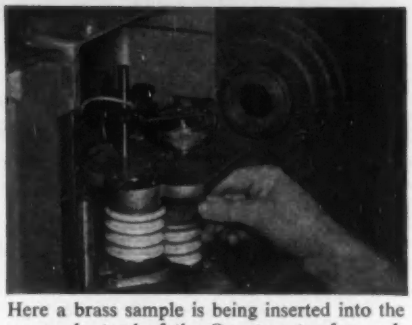
SURE, we're sure you're getting the right copper alloy!



CHASE metallurgists use fantastically accurate instruments to check the brass shipped to you in wire, rod, sheet or tube.

The Quantometer, for instance, tests a brass sample for 18 elements in 1½ minutes.

An Electron Microscope, Spectroscope, and an X-ray Diffraction Unit are also part of Chase laboratory equipment so that we can be absolutely certain that the Chase brass you buy has exactly the right composition, grain structure, temper, dimensions and other physical characteristics your product requires.



Here a brass sample is being inserted into the arc-spark stand of the Quantometer for analysis. In a matter of only 1½ minutes, sample will be completely analyzed.

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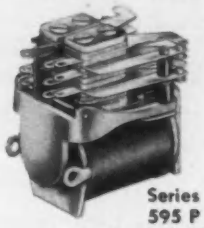
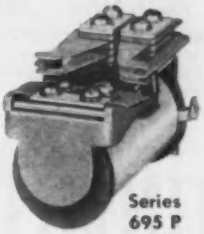
INCREASE POWER — SAVE WEIGHT — SAVE SPACE

Because of keener competition, today's products are being designed with a watchful eye toward economy and sustained high quality. Guardian Relays are right in line to help design engineers conserve space, reduce weight and meet power requirements with plenty to spare. This is exemplified by Guardian's lightweight midget Communications Relays, Series 595-P, 595-H (Hermetically sealed in accordance with MIL-R-6106), and 695-P. Features: (1) new, improved *field piece* with enlarged end adjacent to armature retards magnetic reluctance; (2) *armature* pivots on a stainless steel *pin bearing* to minimize friction and utilize maximum power; (3) maximum electrical separation is obtained between left and right hand contact stacks by means of fiberglass barrier; (4) *magnetic circuit efficiency* assured by correct combination of winding to core size for sensitive or power types.



Series 595 P
Up to 4 P.D.T.

Series 595 H
Up to 4 P.D.T.



Series 695 P
Up to 6 P.D.T.

Series 595-P, up to 4 P.D.T. contact switches, weighs (D.P.D.T.) 2.5 oz. Series 595-H carries up to 4 P.D.T. Series 695-P, up to 6 P.D.T., weighs (D.P.D.T.) 3.5 oz. Write for complete details now.

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- Automatic Wave Changing on Short Wave Transmitters
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- Appliance Controls
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- Alarms, Traffic Signals
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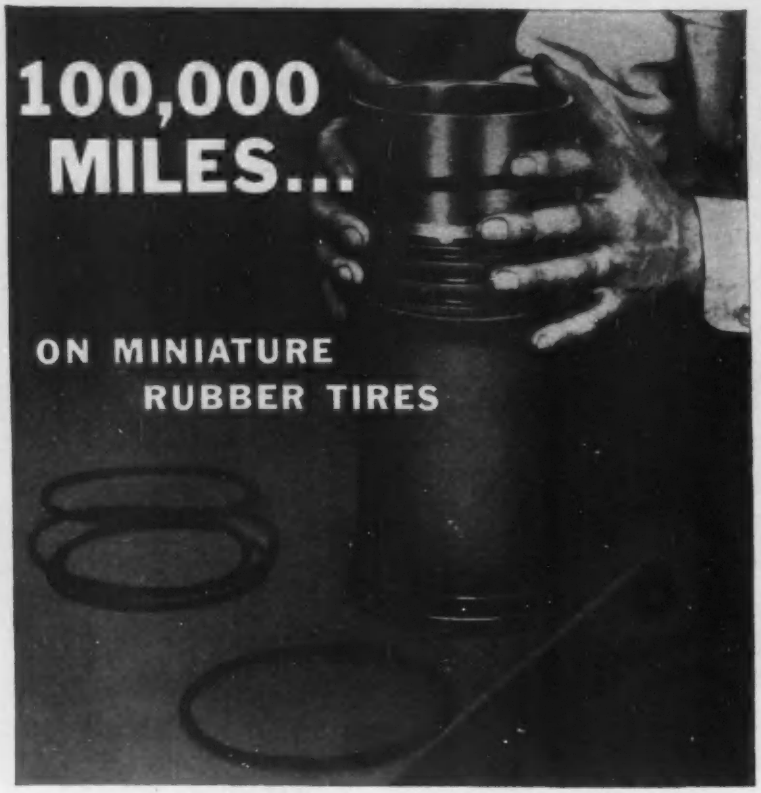

Photograph courtesy of
Cummins Engine Company, Inc., Columbus, Indiana

Tire-shaped rubber packing rings for cylinder liners in Cummins diesel engines are small but important. They provide a seal between oil and water—a seal that must be perfect whether the engine is cold or operating at high temperatures. Moreover, these rubber rings must stand up for at least the equivalent of 100,000 miles of operation.

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Continental met all these specifications and produced a rubber ring that gives outstanding service in an outstanding diesel engine.

The successful production of this specialized rubber part is typical of the complete service in rubber offered by Continental.

When *you* need molded or extruded rubber parts, why not enlist the assistance of Continental?

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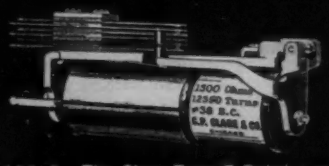
FAST OPERATE—FAST RELEASE—The Clare Type C relay will operate in from 0.005 to 0.04 second, depending on voltage applied, coil resistance, and contact assembly. Release time is from 0.006 to 0.020 second.

SLOW OPERATE—The Clare Type D Relay uses a low resistance copper slug to delay its operation. Operate time can be varied, from 0.01 to 0.1 second, by coil selection. Release time can be held low by heavy spring pressures and large residual settings.



SLOW RELEASE—The Clare Type E Relay uses a copper slug on the heel end of the coil to hold circuits operated from 0.05 to 0.3 second after the coil circuit has been broken. Operate time is from 0.01 to 0.04 second.

SLOW ACTING—The Clare Type H Relay uses dead-soft copper sleeve over coil core to delay buildup of magnetic flux so as to retard operation and release. Operate time may be from 0.01 to 0.05 second; and release time, from 0.03 to 0.3 second.

SNAP ACTION—The Clare Type CMS relay has enclosed snap-action switch contacts, rated at 10 amperes, 125 volts a-c

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TAKEN OFF–PUT BACK–BUTTONED TIGHT

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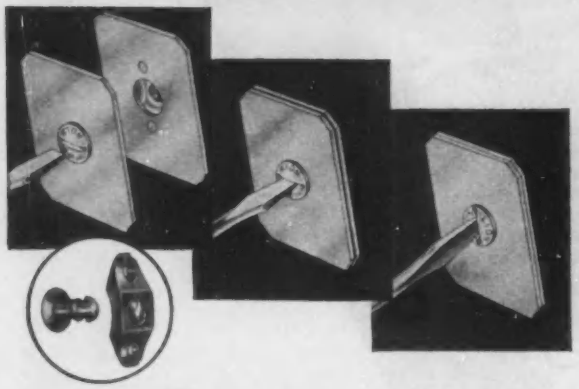

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We base our price on the class of gear depicted on the chart. Our interpretation is based on AGMA Standards for fine-pitch gears.

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CHELSEA, MICHIGAN, Box 328
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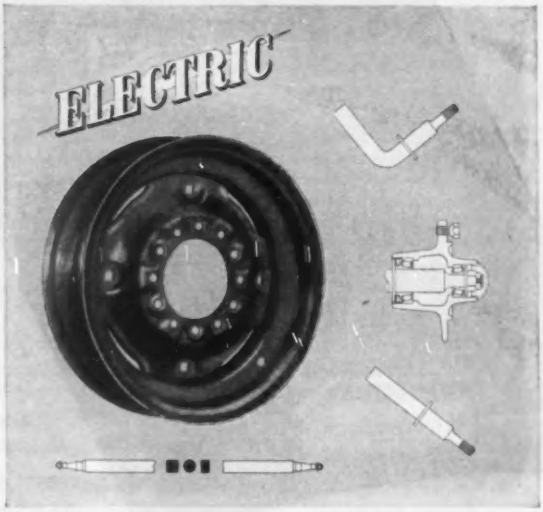

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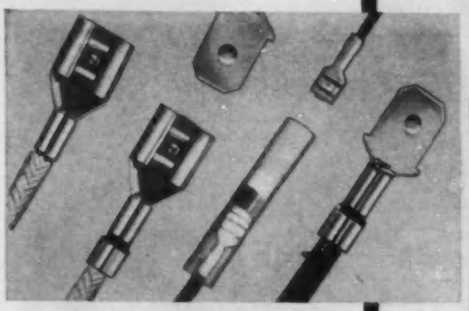
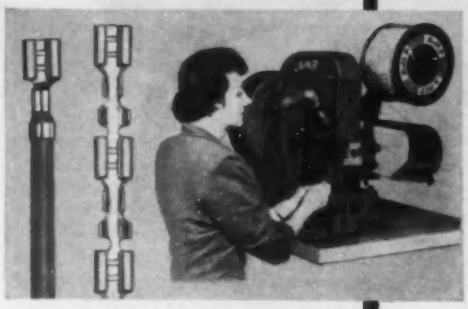


Shown above: AMP FASTON connectors with and without insulation support, FASTON insulated splice connector, FASTON TAB on wire. Also available are a wide selection of tabs for component application.



AMP FASTON connectors can be attached as fast as operator can insert wires in AMP AUTOMATIC MACHINE (up to 4,000 per hour!). Connectors are provided in strip form wound on convenient reels. Hand tools are also available.

A few of the typical appliance components adapted to receive AMP FASTON connectors. Cost is usually reduced through simplified design or elimination of binding screws, clips, etc.

CONNECTORS

are Sweeping the Electrical Industry!

More and more manufacturers are getting into the swing to AMP FASTON CONNECTORS! Timers, clocks, switches, outlets, controls—all types of electrical components when equipped with FASTON tabs not only *cost less* to produce, but offer all the advantages of easier, faster wiring on the line.

Easier and faster because AMP FASTON connectors can be applied to wires at high rates of speed (up to 4,000 per hr.). Then, to install, simply push FASTON on its mating tab. Wiring is accomplished in a fraction of the time required for screw-type terminal posts!

Triple spring action and wide wiping contact of AMP FASTON provides excellent electrical connection. U.L. approved, patented, AMP F CRIMP is voidless—gives high tensile strength and resists corrosion even under most humid conditions. Uniform, precision-engineered terminations eliminate service problems.

FASTON connectors, terminals, and splices cover all insulation ranges in wire sizes #18 through #12 A.W.G. Write today for information and samples!

AMP Trade Mark Reg. U.S. Pat. Off. © AMP

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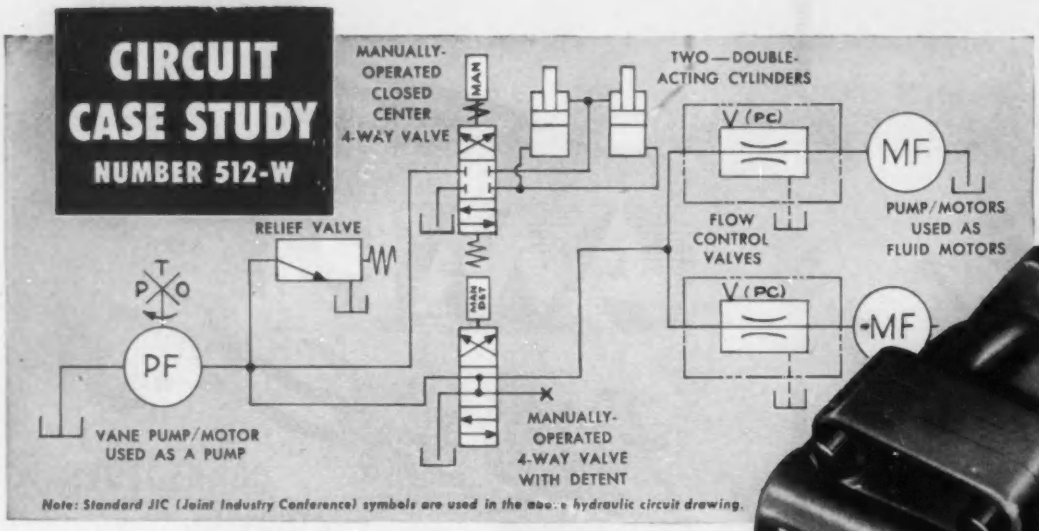
2100 Paxton Street, Harrisburg, Pennsylvania

In Canada . . . . Aircraft-Marine Products of Canada, Ltd.
1764 Avenue Road, Toronto 12, Ontario, Canada



Underwater weed-cutters powered by DENISON HydrOILic Pump/Motors

Unusual Circuit Also Features Denison Valves and Controls

Denison Controls and **Pump/Motors** power triple cutter bars in a fleet of boats specially developed to clear shallow inland waterways of weeds and other vegetation.

The circuit, shown above, affords positive control and power to three cutter bars, mounted on each side and across the bow of the boats. It replaces a complex, hazardous mechanical setup of open, rotating shafts, gears, pulleys, chains and belts.

The gasoline engine which powers the boat also drives a Denison **Pump/Motor** which acts as a pump.

Two additional **Pump/Motors**, one at the rear of each side-mounted cutter bar, drive the cutters through 5-to-1 reduction gearing and eccentrics. Drive rods delivering power to the cutters are interconnected by bell cranks.

A Denison 4-way valve, with detent, controls these two **Pump/Motors.** The detent permits the operator to leave the valve in either the "operating" or "off" position without holding the lever.

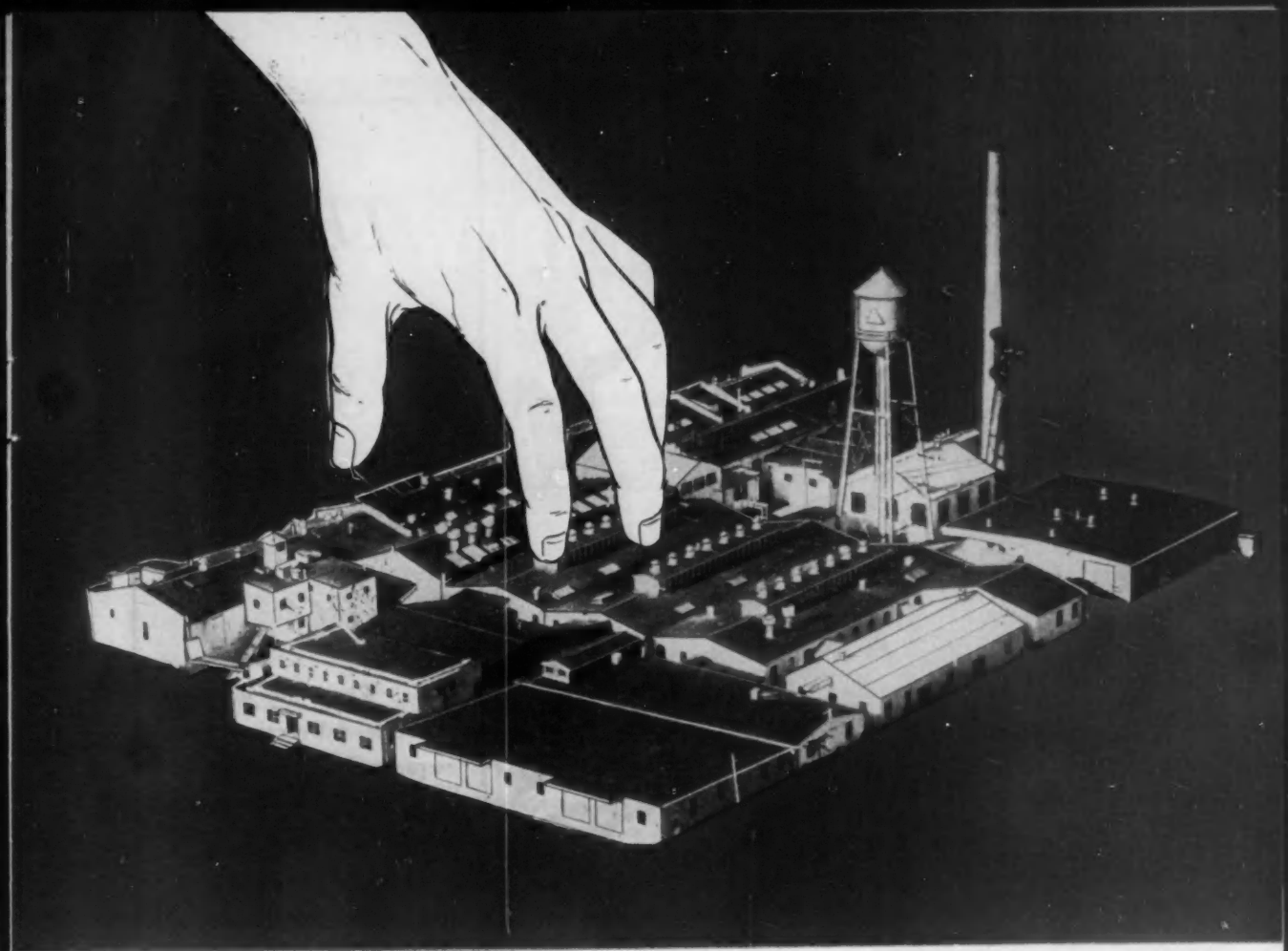
A Denison relief valve limits system pressure to the maximum pre-set rating. The mechanical linkage formerly used was subject to severe damage if the cutters struck an obstacle. Now, however, the cutters merely stall, and excess flow "spills" through the relief valve.

A second Denison 4-way valve with a closed-center spool controls double-acting cylinders which raise and lower the cutter bars. By simply centering this valve control, the operator can hold the cutters at any height.

This type of circuit emphasizes advantages of Denison **Pump/Motors.** Each unit is ready for either pump or motor duty *without alterations!* A single "spare" can replace any of the three units, in any of the boats. **Pump/Motors** are single-stage, vane-type power packages with hydraulically balanced vanes, and simplified three-unit construction. They stand up under *long, hard, continuous duty* at pressures up to 2000 psi. Four sizes—each with a choice of cam rings for different needs—offer pumping capacities from 3 to 82 gpm . . . motor capacities from 8 to 98 hp (13 to 257 inch-pounds of torque per 100 psi.) All models can provide either clockwise or counterclockwise rotation.

Denison offers an outstanding line of high pressure oil hydraulic pumps, motors and controls, for pressures to 5000 psi. Designed with skill and knowledge gained through twenty-five years of leadership in oil hydraulics, they have the compact ruggedness needed for exacting, heavy-duty demands. Wherever you need closely adjustable power and control with unlimited operating flexibility, specify HydrOILics. Write for more details.

The DENISON Engineering Company, 1157 Dublin Road, Columbus 16, Ohio



Raising the Roof at Aico . . .

Things have been humming at Aico. Every user of molded plastics has an interest in what has been going on in our big modern plant.

Raise the roof . . . take a look inside. You'll see a vast improvement program as it nears completion, to make Aico one of the most versatile, finest equipped of all plastic molders.

Big, new molding presses . . . the latest preheating and finishing equipment . . . rearrangement of production facilities . . . all contribute to producing better plastic parts through greatly improved scientific control of materials and sharply increased production efficiency.

Now, even more than before, Aico makes it possible to simplify your buying of plastic parts by placing all your orders under one roof. With complete compression, injection, cold molding and low pressure molding departments, Aico is one of the limited few plastic parts suppliers in a position to make an unbiased recommendation on the most practical and economical method of molding.

Our engineering people are here for the purpose of advising you on the proper use of molded plastics. The use of this service involves no obligation. Just drop us a line if you think we can be of assistance to you.

AMERICAN INSULATOR CORPORATION
NEW FREEDOM, PENNSYLVANIA

Aico's Complete Plastic Molding Service Includes:

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MOLD BUILDING to avoid division of responsibility.

INJECTION MOLDING for high rate of production . . . low unit cost.

COMPRESSION MOLDING of large parts with heavy cross sections.

COLD MOLDING of electrical parts requiring high heat resistance.

REINFORCED PLASTICS . . . a relatively new development in low pressure molding of reinforced resins.

MANY THINGS ARE BETTER BECAUSE OF . . .

Aico PRECISION MOLDED plastics

Roth (RR) Rubber Molds Shock-Resistant Aircraft Transformer Case!

Easier to assemble and seal than the old fashioned metal case, the shock-resistant rubber molding by Roth for the Jefferson Electric Company has other significant advantages: it is corrosion-resistant, oil-resistant; and it provides *complete protection* to its contents against high altitude conditions and the extremes of arctic and tropical weather. Roth engineers solved this problem—they can solve *yours!*

Roth Research Brings Results With Rubber

Engineers and Rubber Buyers!

Write for your free Roth Rubber Sampler. This unusual kit contains actual rubber samples with hardness from 5 to 100 Durometer . . . gives ASTM specs and lists uses for each sample. Sorry, but offer must be limited to engineers and rubber buyers only. Please ask for Roth Rubber Sampler No. PE3.

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. . . Whose one job is to expedite delivery of your requests for "New Catalogs and Bulletins" to the manufacturers concerned.

The job keeps her busy, too. She handles several thousand requests from **Product Engineering** readers every month. And she's anxious to be of service to you whenever she can.

So check the "New Catalogs and Bulletins" insert if you haven't already done so. You'll find a lot of useful information listed there . . . and any of it is available to you promptly and without cost.

Product Engineering

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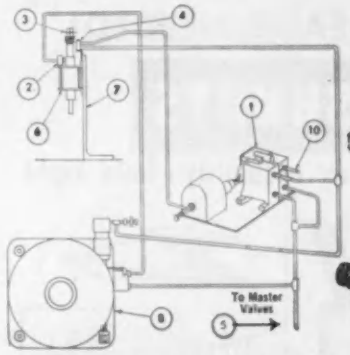
ROTARY WORK FEEDER

IN ACTION!

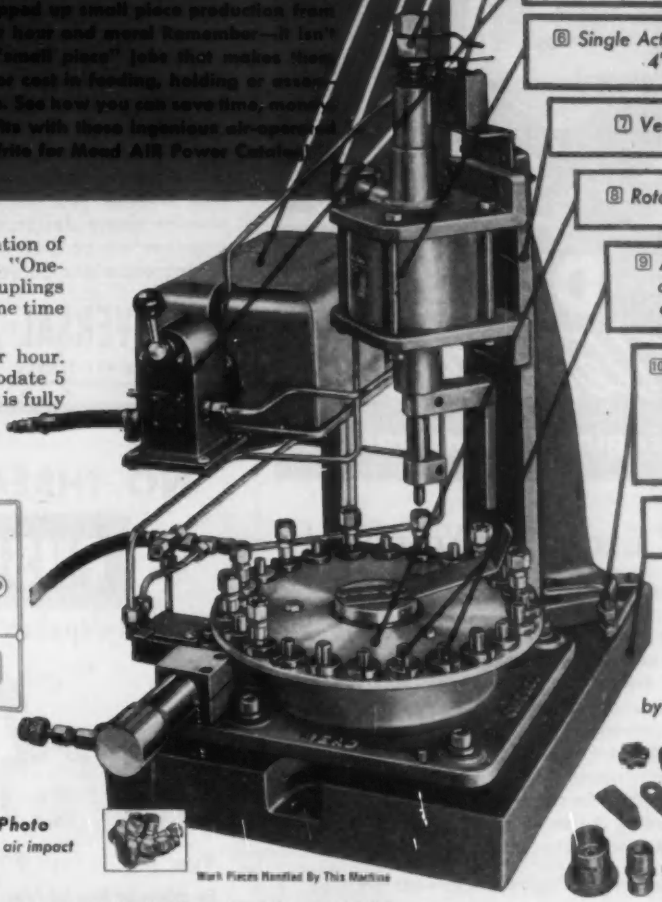
TIME and again Mead Work Feeders—using clean, inexpensive Air Power—have stepped up small piece production from 200 to 2,000 pieces per hour and more! Remember—it isn't the material in these "small piece" jobs that makes them expensive—it's the labor cost in feeding, holding or assembling them. Get the facts. See how you can save time, money, labor and increase profits with these ingenious air-operated MEAD Work Feeders. Write for Mead AIR Power Catalog.

A simple and inexpensive combination of Mead pneumatic devices makes a "One-Man Factory" to assemble brass couplings by flaring neck into nut, at the same time forming a fluid-tight seat.

Output approximately 2500 per hour. Two sets of 12 mandrels accommodate 5 different styles and sizes. Operation is fully automatic except for loading.



Circuit Diagram of Units in This Photo
Combine readily to feed work to drill press, air impact hammer for a wide variety of operations.



Work Pieces Handled By This Machine

1. Model 2 Meadmatic Timer
2. #2 Quick Exhaust Valve to speed up return stroke
3. Adjustable depth stop with spring return
4. Cycle release valve (included with timer) to reverse cycle at end of down stroke
5. 4-B Master Valve starts and stops entire system
6. Single Acting Cylinder, 4" bore
7. Vertical Stand
8. Rotary Work Feeder
9. Alternate mandrels for two sizes of brass couplings
10. Air blast ejection of finished parts, by jet piped from second of two valves in timer
11. Universal Base

Typical Work Pieces Handled *by Mead work feeders*

MEAD SPECIALTIES COMPANY, Dept. PE-34, 4114 No. Knox Ave., Chicago 41, Ill.

Memo Coupon

MEAD SPECIALTIES CO.
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Send free copy of new, colored MEAD INDUSTRIAL AIR POWER CATALOG describing the complete line of famous Mead air-operated devices.

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proven on most diesel makes and models

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The *BEST* Choice For Your Needs

If you're concerned with the design of lubricating oil or cooling systems for jet, heavy-duty gasoline or diesel engines it will pay you to specify DETROIT Vernatherm Engine Thermostats. For only DETROIT Engine Thermostats give you the assurance of dependable, efficient operation performance proven on military and commercial aircraft . . . on ordnance combat vehicles . . . and on most diesel makes and models. So take advantage of this outstanding record—specify DETROIT Vernatherm Engine Thermostats, the true standard of the industry for rugged, exacting service! Available as engine cooling thermostats, oil cooler thermostats, shutter thermostats and thermostatic power elements.

All DETROIT Vernatherm Engine Thermostats are . . .

- *Designed to work with either open or closed cooling systems*
- *Not affected by barometric pressure*
- *Built with tight seats for minimum leakage*
- *Not subject to chatter*

ESTABLISHED IN 1877 AS DETROIT LUBRICATOR COMPANY

DETROIT Controls CORP.

DETROIT 8, MICHIGAN Division of American Radiator & Standard Sanitary Corporation
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AUTOMATIC CONTROLS for REFRIGERATION
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The high dielectric and physical strength of porcelain resists hot electrical arcing, extreme temperatures, moisture, fumes and chemicals. Combine these advantages with Universal's ability to produce porcelain pieces that meet exact design requirements — any shape or size, with close tolerance dimensions and uniform body — you have an insulator that will add to the performance and service life of the electrical unit. Whether your insulator requirements call for complex or simple design, long or short run, a Universal engineer will be glad to offer helpful suggestions and recommendations on your next job.

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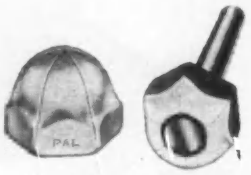
NO THREADS NEEDED!

PUSHNUTS

Trademark

Low cost—speedy assembly—hold tight

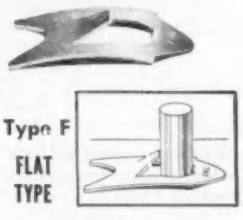


Type C **Type K**

For unthreaded Rods and Axles

Used on wheels of play vehicles; also other permanent applications.

Place PUSHNUT on rod, tap with hammer. Patented locking method resists 100 lbs. or more. Eliminates threading, notching, cotter pins. Made of heat-treated spring steel, in pleasing acorn or semi-acorn styles and various finishes, for 3/16", 1/4" and 5/16" rod.



Type F FLAT TYPE

For unthreaded Studs and Rods

Ideal for nameplates, mouldings and other light parts.

Slips easily over stud, instantly locks with push of simple inexpensive applicator. Spring tension pulls parts snugly to base—energized grip holds tight against loosening or rattling. Choice of finishes for 3/32", 1/8" and 3/16" studs.

Write for free samples, stating size and application.

THE PALNUT COMPANY

Manufacturers of PALNUT® Lock Nuts and Fasteners
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In Canada: P. L. Robertson Mfg. Co., Ltd., Milton, Ont.

LORD MOUNTINGS *Protect Vital Parts* *on* EVERY TYPE of AIRCRAFT

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FOR more than a quarter century Lord Headquarters for Vibration Control have designed and manufactured bonded-rubber mountings to protect vital aircraft components from vibration and shock . . . to improve the overall operation of aircraft . . . to contribute to passenger and crew comfort. Among the many well known Lord Mountings in the Aviation Industry are (1) Dynafocal Engine Suspensions (2) Instrument Panel Mountings (3) Antennae and Electronic Equipment Mountings (4) Cowl Mountings (5) Actuator Attachment Mountings. There are many others.

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start with sand

add natural gas

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silicone rubber

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heat and cold proof
(from 100 below to 500 above)

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COHRLASTIC silicone rubber coated fabrics are made for special purposes, are entirely new and unique — without a counterpart. Organic rubber breaks down and melts under high heat, cracks like glass at temperatures below —50°F. Other materials do not have the strength required to serve under conditions encountered in stratosphere flying or hot-spot electrical components. Some of these fabrics are fortified with Dacron, Nylon, Orlon or Fiberglas when necessary. Orlon brings long flex-life; Fiberglas, the strength of steel; Dacron and Nylon, great wearing and weathering power. Even the characteristics are fabulous — remarkably low compression set, high dielectric strength, resistance to hot oil, hot gas, fly ash, coolants, mild acids and alkalies, infrared rays. We recommend these fabrics to you with complete confidence for bellows, boiler seals, diaphragms, duct tunnels, expansion joints, fire curtains, oven conveyor belts, steam generator installations, transformer windings, vibration dampers.

Samples and Price List on request

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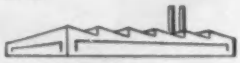
Functional Design

an **ADVANCE RELAY** *for every application*



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Unsurpassed relays for commercial and industrial applications. Advance can meet all requirements. They offer a complete line of rugged precision-built relays for your specific needs.

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Designed for demands of minimum cost, compactness and dependability, Advance Communication Relays should be the number one choice for your valuable equipment. Each Advance Relay *must* and *does* meet the highest standards of precision and quality.

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Advance offers a complete line of AN approved, quality engineered relays for aircraft. They meet or surpass all Military and Civilian requirements. All are lightweight, compact and rugged. Some models available hermetically-sealed.

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Aeroquip

"little gem" FITTINGS

aeroquip did it again!

Another Important Development in Detachable, Reusable Hose Fittings!

KNIFE-LIKE SPUR separates hose inner tube and reinforcing wire braid during assembly.

CLAMPING ACTION, between nipple and socket, is exerted on reinforcing wire braid only.

POSITIVE LIP SEAL is formed by end of inner tube in annular chamber.

Here's another great Aeroquip first . . . "little gem" Fittings with radically new features never before seen in the industry! These amazing new fittings were especially designed to prolong the life of certain types of hose made of rubber or rubber-like materials, and plastics. Under extreme compression these materials tend to take a definite set and flow away from the zone of compression. This action is accelerated by heat. Through advanced research, development, and engineering, Aeroquip was able to provide the answer to this problem. "little gem" Fittings are now in production for Anti-Icing Hose Lines used on aircraft jet engines, and Steam Hose Lines in the industrial field.

"little gem" is an Aeroquip Trade Mark

AEROQUIP CORPORATION, JACKSON, MICHIGAN

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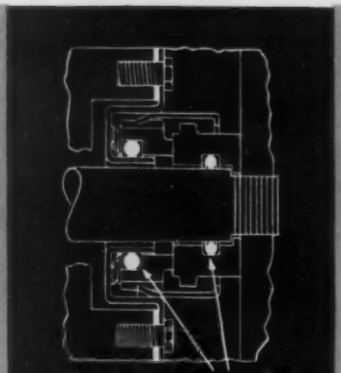
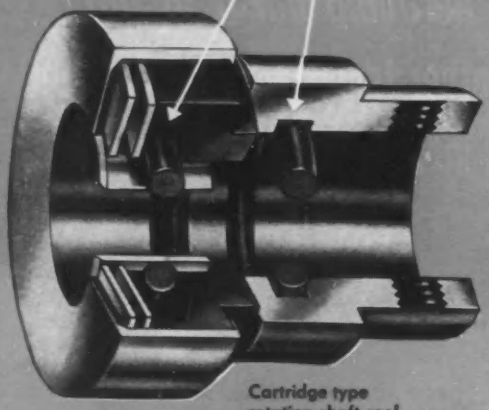
AEROQUIP PRODUCTS ARE FULLY PROTECTED BY PATENTS IN U.S.A. AND ABROAD

Precision "O" Rings assure



Drawing employing 2 Precision "O" Rings in a typical Cartriseal Unit

proper cushioning, perfect performance, positive sealing for CARTRISEAL UNITS



Cartridge type rotating shaft seal

Compact, dependable cartridge type sealing units, made by *Cartriseal Corp.* of Chicago, replace bulky, old-fashioned packing rings and solve many rotating shaft sealing problems. In order to assure *highest quality* and positive, leak-proof service, *Cartriseal* engineers specify *Precision* "O" Rings for these hydraulically balanced, easy-to-install units!

Everyone is finding Precision "O" Rings the best answer to many sealing problems — and they are finding, too, that *Precision* leads the field in engineering help. Let us help you. Send for our "O" Ring Handbook and let us have your inquiries.

FREE — Write for your personal copy of our Handbook on "O" Rings.

Precision Rubber Products CORPORATION

"O" Ring and Dyna-seal® Specialists

Dept. 3, Oakridge Drive, Dayton 7, O. Canadian Plant at: Ste. Thérèse de Blainville, Québec

Chiksan Swivel Joints SAVE TIME AND MONEY IN JOHNSON MOTORS DIE CASTING DEPARTMENT

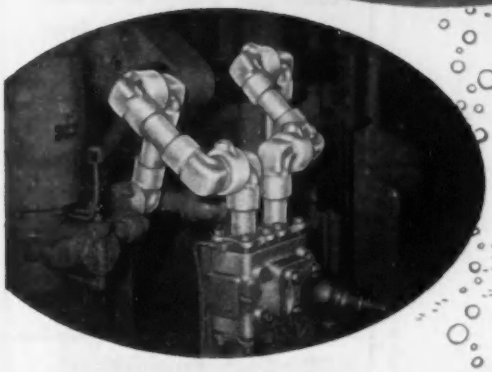
Fluid losses cut 75%!

Setting up time reduced 75%!

Safety of its people and property, plus increased efficiency and economy of operation, were the chief considerations which turned Johnson Motors to Chiksan Swivel Joints.

Johnson Motors die-casting department, one of the largest in the Middle West — and the largest captive plant in this country — selected Chiksan hydraulic swivel joints when it converted its machines from flammable oils to nonflammable hydraulic fluids.

Forty-eight package die casting machines are operated on a staggered three shift basis, producing more than 400 aluminum alloy die castings ranging from ½ ounce to 11 pounds in size. Hydraulic systems are operated at pressures up to 2000 psi, with average total die forces in the range of 300 to 500 tons. Castings are made at temperatures between 1100° and 1200° F.



Chiksan ball-bearing swivel joints installed on Lester-Phoenix die-casting machine helped Johnson Motors meet its fluid cost problems.

Chiksan ball-bearing swivel joints have helped to reduce fluid losses from 40,000 gallons per year to 10,000 gallons. In contrast to former loss of from 1 to 3 gallons in repositioning bolted lines, Chiksan joints permit resetting of table level with virtually no fluid loss. Time consumed in resetting table levels has been reduced from 2 men and 1 hour to one man and 15 minutes of time.

This story is typical of the many ways thousands of manufacturers are using Chiksan ball-bearing swivel joints for greater safety, efficiency, and economy in their operations.

For Safety, Economy and Efficiency in your die casting department Chiksan has plans and applications worthy of your immediate and serious consideration.

Write CHIKSAN Engineering Research Division today for our NEW Catalog No. 53-C, Dept. 3-PE.

The Flow of Enterprise Relies on **CHIKSAN**

Ball-Bearing Swivel Joints

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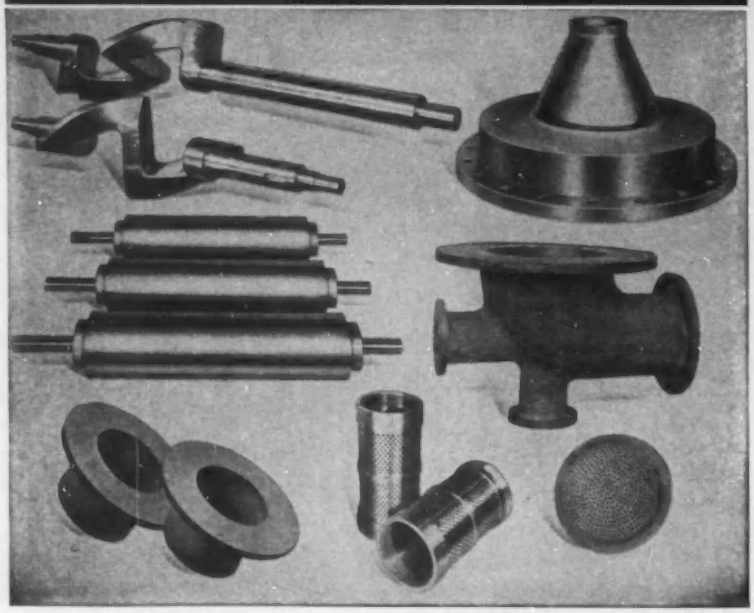
MISCO *Stainless Steel* CASTINGS

CORROSION RESISTING · HEAT RESISTING · WEAR RESISTING



MISCO engineering, metallurgical and production facilities are at your service. We are pleased to furnish specific information on the proper analysis, design and application of stainless steel castings for best resistance to corrosion, heat and wear. Bulletins and engineering data sheets available upon request. Let us know your needs.

LARGE AND MEDIUM WEIGHT STAINLESS STEEL CASTINGS • CENTRIFUGAL CASTINGS • CENTRIFUGALLY CAST STAINLESS STEEL PIPE AND TUBES

Michigan Steel Casting Co.

DIVISION OF EBALOY, INCORPORATED

One of the World's Pioneer Producers of Heat and Corrosion Resisting Alloys

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Heat and Corrosion Resistant Alloys

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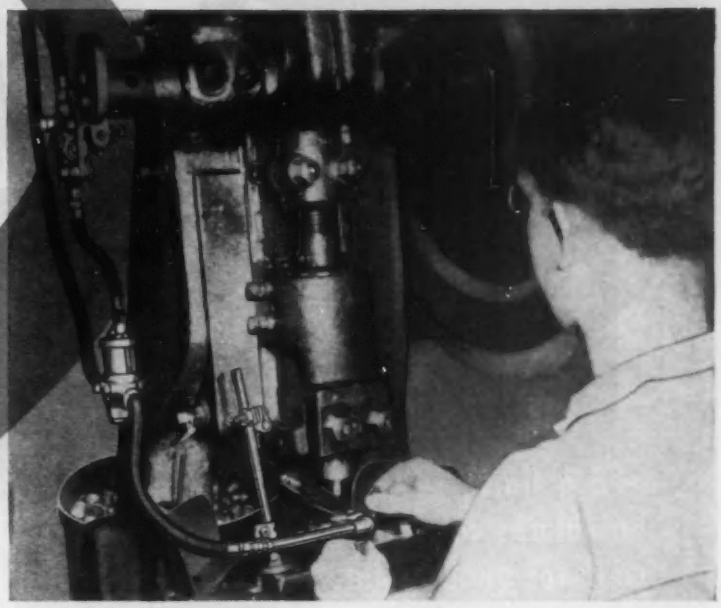
how much can air ejection boost your production

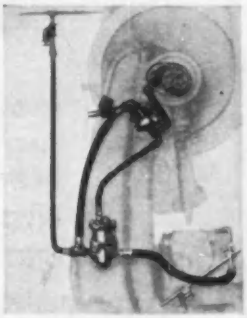


Actually, it can *double production.* With Schrader Air Ejection Sets on your presses, after each press cycle, there's a quick puff of air—automatically timed to do the job just right—and you're set for the next blank to be inserted.

No more tedious, dangerous hand removal!
No more wasteful steady air blasts!

Schrader Air Ejection Sets come in many types to suit any need. You can buy them for cam operation off the crankshaft, or for roller tripper actuation from the ram. If the parts you are fabricating are too heavy to be blown from the dies by an air blast, the Schrader Cylinder Knockout Set is available, which utilizes the knockout force available from a push-type Schrader Cylinder.

But regardless of the type of ejection set you need, you'll find one exactly suited to your requirements at Schrader. Schrader Air Ejection Sets come complete with all necessary fittings, valves, hose and air line accessories—all ready to be bolted to your press. Write today for full details.



This is the Schrader No. 3208W Air Ejection Set. Similar sets are available for cam or tripper operation, with or without pilot valve timing.

Schrader
REG. U. S. PAT. OFF.

leaders in air control since 1844

Air Cylinders • Operating Valves • Press & Shear Controls • Air Ejection Sets • Blow Guns • Air Line Couplers • Air Hose & Fittings • Hose Reels • Pressure Regulators & Oilers • Air Strainers • Hydraulic Gauges • Uniflare Tube Fittings

Mail This Coupon Today

A. SCHRADER'S SON
Division of Scovill Manufacturing Company, Incorporated
477 Vanderbilt Avenue, Brooklyn 17, N. Y., Dept. U-2

I am interested in more information on.....

Name_____ Title_____

Company_____

Address_____

a special message for appliance manufacturers

need a finish that blocks corrosion by itself—or under paint? specify IRIDITE

You can solve any problem of non-ferrous finishing . . . maximum corrosion protection . . . sparkling clear or colored decorative finishes, firm and lasting base for paint . . . with these two words—"specify Iridite". For example—

- **ON ZINC AND CADMIUM** you can get highly corrosion resistant finishes to meet any military or civilian specifications and ranging in appearance from olive drab through sparkling bright and dyed colors.
- **ON COPPER . . .** Iridite brightens copper, keeps it tarnish-free; also lets you drastically cut the cost of copper-chrome plating by reducing the need for buffing.
- **ON ALUMINUM** Iridite gives you a choice of natural aluminum, a golden yellow or dye colored finishes. No special racks. No high temperatures. No long immersion. Process in bulk.
- **ON MAGNESIUM** Iridite provides a highly protective film in deepening shades of brown. No boiling, elaborate cleaning or long immersions.

AND IRIDITE IS EASY TO APPLY. Goes on at room temperature by dip, brush or spray. No electrolysis. No special equipment. No exhausts. No specially trained operators. Single dip for basic coatings. Double dip for dye colors. The protective Iridite coating is not a superimposed film, cannot flake, chip or peel.

WANT TO KNOW MORE? We'll gladly treat samples or send you complete data. Write direct or call in your Iridite Field Engineer. He's listed under "Plating Supplies" in your classified telephone book.

ALLIED RESEARCH PRODUCTS
INCORPORATED
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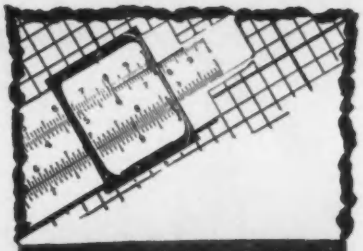

FOR BETTER SPEED CONTROL USE Servospeed

MODERN ELECTRONIC ENGINEERING GIVES PRECISE

FINGERTIP SPEED CONTROL

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- MOTOR INTEGRATORS
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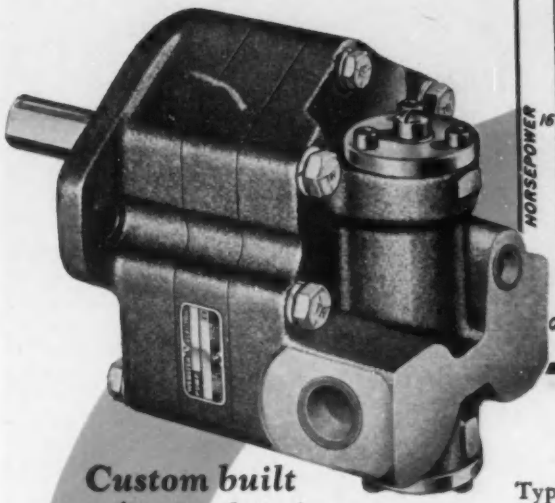
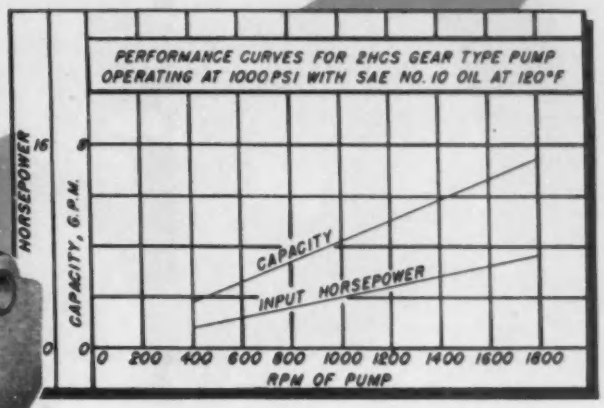
- SERVO CONTROL

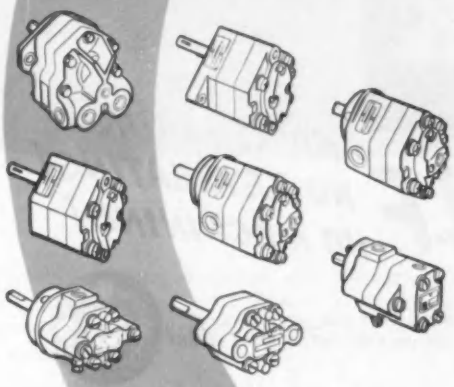
Servospeed
4 Godwin Ave. Paterson, N. J.

Check this typical **WEBSTER** Hydraulic Pump Performance Curve





Custom built *for easy adaptation to your system*

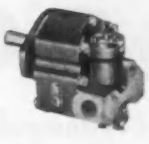


• It will pay you to get the facts about WEBSTER Gear-Type Hydraulic Pumps before buying any pump. Here is a complete line of rugged, dependable pumps from 10 gph. to 10 gpm., engineered to operate efficiently at pressures up to 1200 psi. at speeds of 3600 rpm. or less—90 types of WEBSTER Oil Hydraulic Pumps of various designs and capacities to meet the widest range of requirements!

• WEBSTER pumps are the product of skill acquired during nearly a quarter-century of experience. They have established an enviable reputation for efficient, dependable operation. All WEBSTER pumps lend themselves readily to many forms of adaptation—and to modification for special installations. All are available with built-in relief valve, if desired.

• Whenever you require pumps for lubricating, oil circulating, filtering, transfer or quiet hydraulic power applications, we invite your inquiries.

Write *today for catalog containing performance charts and pump data sheets on which you can describe your requirements*



OIL HYDRAULICS DIVISION

WEBSTER ELECTRIC

RACIRE, WISCONSIN

ESTABLISHED 1909

"Where Quality is a Responsibility and Fair Dealing an Obligation"

MANUFACTURERS OF A COMPLETE LINE OF OIL HYDRAULIC PUMPS

TAPER-LOCK

A PATENTED PRODUCT OF DODGE

—OFF THE SHELF

NO REBORING!
NO KEYSEATING!
NO MACHINING!

Ready for the shaft, with no costly, time-consuming operations to make them fit. That's the big news about Dodge Taper-Lock Sprockets. Taper-Lock grips the shaft with the firmness of a shrunk-on fit, yet comes off easily. Bushings may be re-used. They come in sizes to meet most every application.

Taper-Lock Sprockets are available from Distributors' stocks in a complete range of B-type steel sprockets—½" to 1¼" pitch. Dodge quality Roller Chain is packaged in 10-foot lengths—also available in 50-foot and 100-foot reels. Save time—save money—keep production rolling—get Dodge Taper-Lock Sprockets and Roller Chain from your Dodge Distributor.

DODGE MANUFACTURING CORPORATION, 1200 Union St., Mishawaka, Ind.

CALL THE TRANSMISSIONEER, your local Dodge Distributor, for valuable assistance on new, cost-saving methods. Look for his name under "Power Transmission Machinery" in your classified telephone directory, or write us.

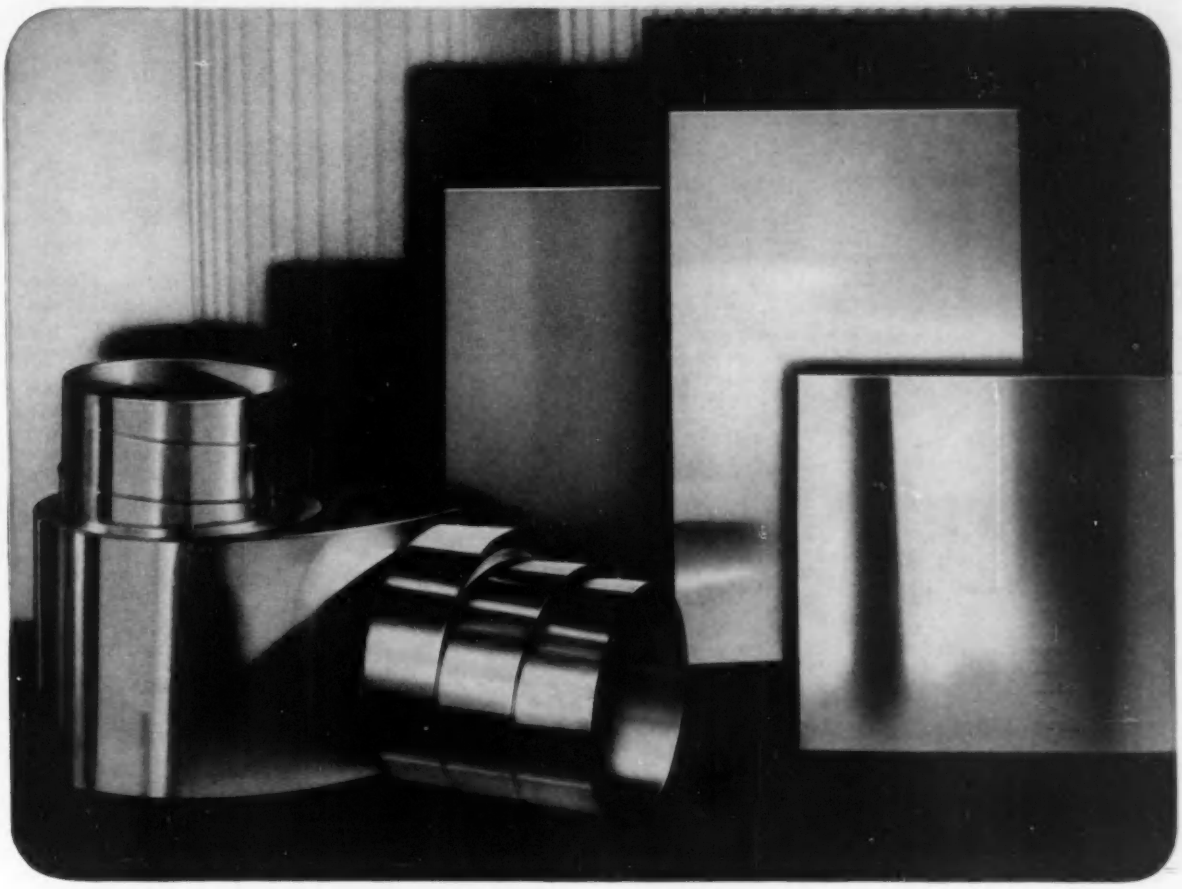
THERE'S ONLY ONE TAPER-LOCK, THE BUSHING THAT MOUNTS FLUSH!

Standardize, economize with Taper-Lock, the bushing that is interchangeable in Dodge sprockets; sheaves, couplings and conveyor pulleys. *More than 2,000,000 in use!*

DODGE

of Mishawaka, Ind.

Nickeloid Metals



LUSTROUS METALS, pre-plated with finishes of chrome, nickel, brass or copper.* *Modern* as tomorrow . . . *practical* as fifty-five years of metallurgical know-how can make them.

Nickeloid pre-plated metals open new fields of product design . . . add new functional beauty that makes your products stand out in the crowd of competition.

Here, too, is production economy . . . a shortcut manufacturing *method*. Pre-plated Nickeloid Metals require no costly, time-consuming cleaning, plating, polishing, painting or lacquering. They are ready for immediate assembly after they are stamped or formed. Nickeloid Metals are used for functional parts or as trim by hundreds of progressive manufacturers.

It will pay you to investigate Nickeloid Metals.

* Pre-plated to following base metals: steel, brass, copper, zinc or aluminum. Available in sheets or coils, and in interesting patterns and crimps.

AMERICAN NICKELOID COMPANY

ADMINISTRATIVE OFFICE: Peru 4, Illinois MILLS: Peru, Illinois and Walnutport, Pa.

MODERN METALS

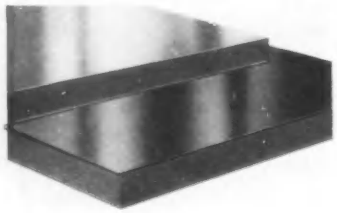
for Modern Industry

EASILY WORKED

Stamp, blank, bend or draw . . . with good shop practice these versatile pre-plated metals can be fabricated just the same as unfinished metals. Supplied with Mar-Not to protect surface if desired. Can also be successfully welded, soldered, riveted, seamed.

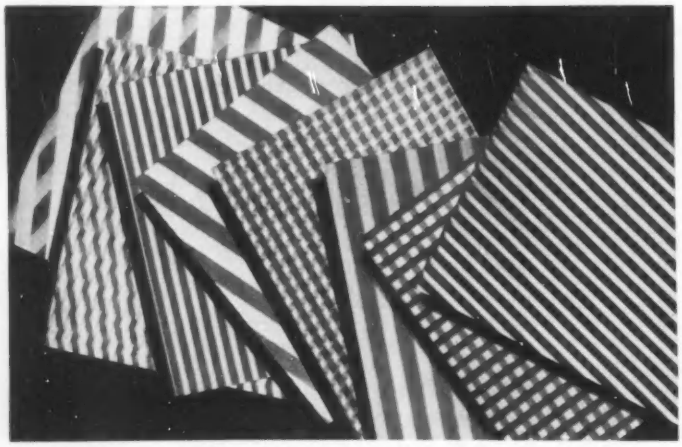
VERSATILE UTILITY

Nickeloid Metals are used extensively and profitably in these fields: electrical appliances, stoves and heaters, housewares, lighting fixtures, displays, stampings and many others. Ingenious designers are constantly opening up striking new uses for these metals.



PROVEN DURABILITY

Hard-finished, durable Nickeloid Metals are easy to keep clean and lustrous. They resist rust, tarnish, abrasion, and corrosion. Electrolytically-deposited finish is guaranteed not to chip or peel. In ordinary use they will not blister or discolor. They are attractive, and stay looking that way longer.

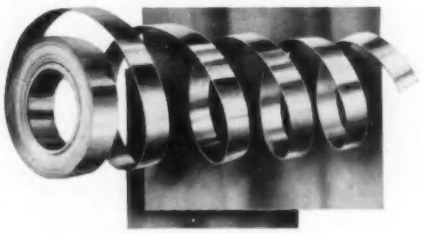


Beautiful crimps and stripes find many interesting and practical applications

Sales offices in most principal cities

FUNCTIONAL BEAUTY

It's more than skin-deep . . . the beauty of Nickeloid Metals. Industrial designers find these lustrous metals ideal for functional as well as decorative parts of products. Progressive manufacturers know that Nickeloid Metals offer an economical way to meet the demand for modern product design. These gleaming metals add the eye appeal . . . the buy appeal that often spells the difference between inventory turn-over and hold-over on dealers' shelves and floors.

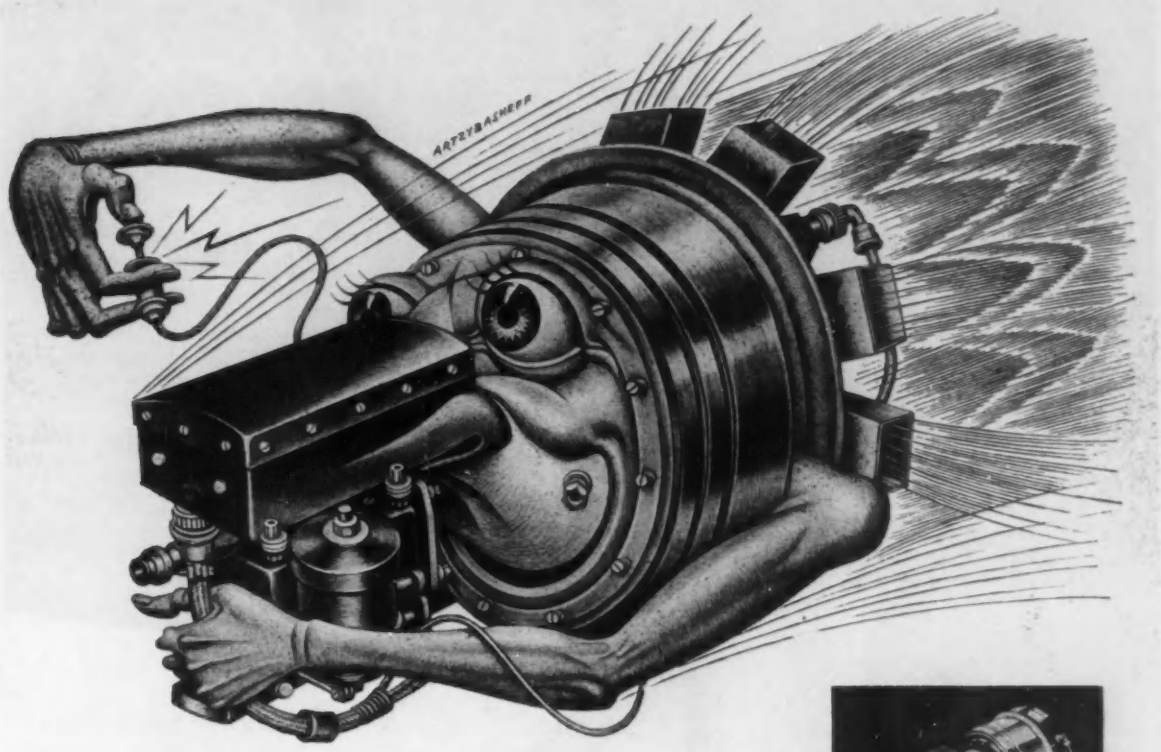


PRACTICAL ECONOMY

Two production steps: fabricate and assemble . . . instead of five: fabricate, plate, polish, buff, assemble. Nickeloid Pre-Plated Metals are a durable finished raw material that provide the shortest distance between raw material and finished product . . . a longer margin between production cost and selling price. It's just good business to take advantage of such a sound production method. We can serve you promptly and well, and will be happy to work with you on your particular problem.

Quality Metals Since 1898

AMERICAN NICKELOID COMPANY
PERU 4, ILLINOIS



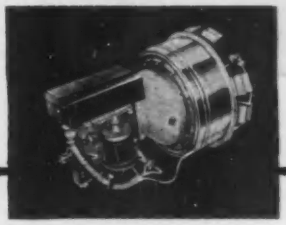
Parts that put new "starts" in jets

Good news for new-born jets! This typewriter-size Bendix Aviation self-starter is *built-in* . . . develops 340 horsepower in just 3½ seconds . . . enables a jet's main engine turbine to reach take-off speed in a matter of seconds after the pilot hits the starter. No more precious minutes lost while ground crews bring up mobile auxiliary starting power!

For 14 of the rugged, dependable, precision-machined parts that make up this self-starter for jets . . . Eclipse-Pioneer Division of BENDIX AVIATION CORPORATION looks to Lycoming.

Do *you* need precision parts . . . or any other of the diversified services listed with our signature? Lycoming's wealth of creative engineering ability . . . 2½ million square feet of floor space . . . and 6,000-plus machine tools stand ready to serve you. *Whatever* your problem . . . *look to Lycoming!*

Just off the press! "THE LYCOMING STORY". . . 40 interesting, illustrated pages showing many ways Lycoming is ready to help you. Write for it on your letterhead.



For 14 major components of the first mass-produced self-contained starter ever built into large jets, Bendix Aviation looks to Lycoming for precision production.

Aircraft Engines
Industrial and Tank Engines
Engine Overhaul
Generating Units

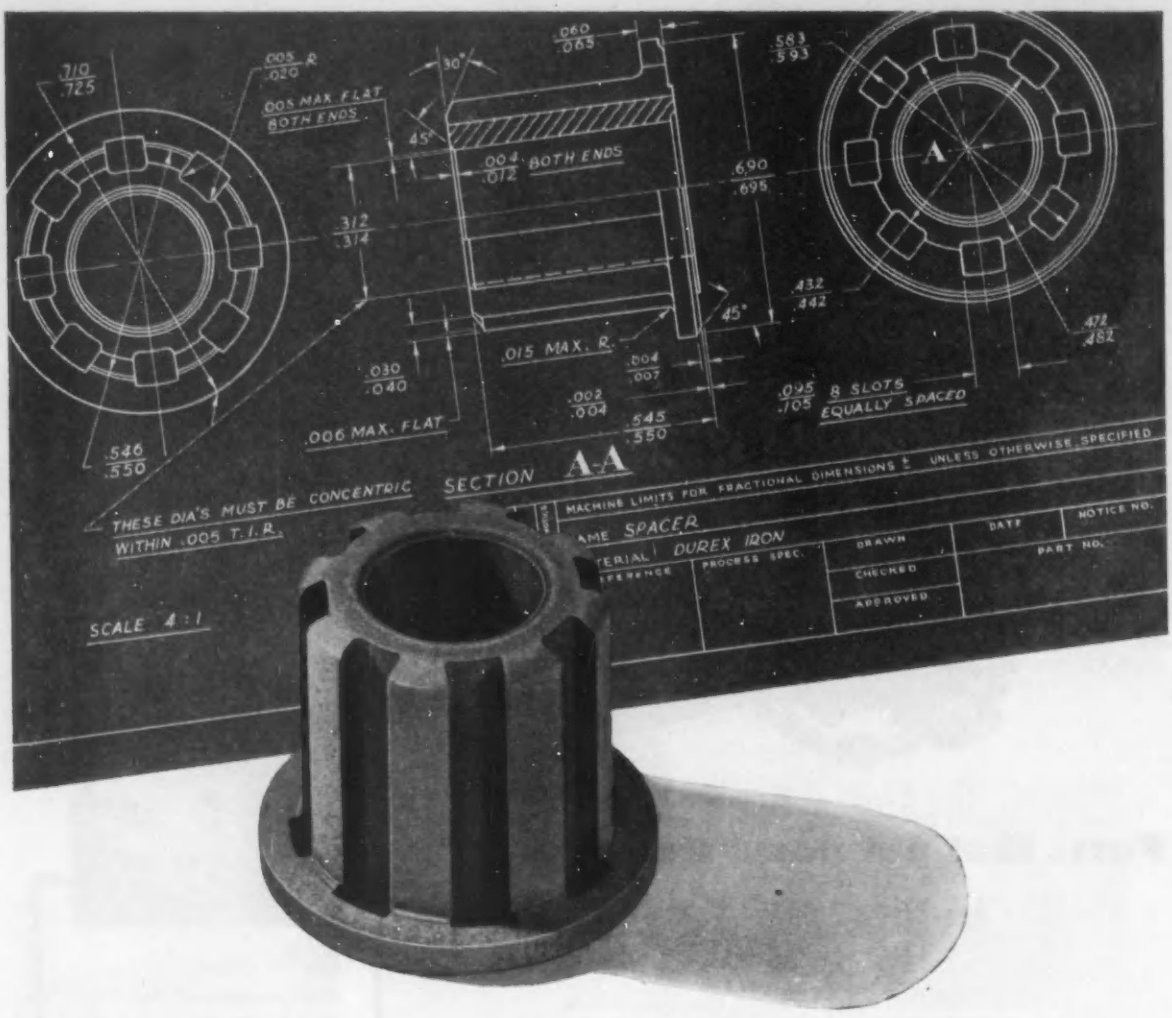
Turbine Engineering and Research
Engineering Design and Development
Hardened and Ground Precision Parts
Gears and Machine Parts

Complete Assemblies
Heat-Treating and Plating
Steel Fabrication
Castings
Boilers

FOR RESEARCH • FOR PRECISION PRODUCTION

LOOK TO **Lycoming**

DIVISION OF AVCO STRATFORD, CONN.
Manufacturing plants in Stratford, Conn., and Williamsport, Pa.



TRICKY DESIGNS ARE EVERYDAY PROBLEMS FOR MORAINE'S METAL POWDER PROCESS

This part would be a *real* problem to make economically by conventional casting and machining methods. At Moraine it's made from metal powder—easily, in quantity, every day—to precision standards—with important savings in cost!

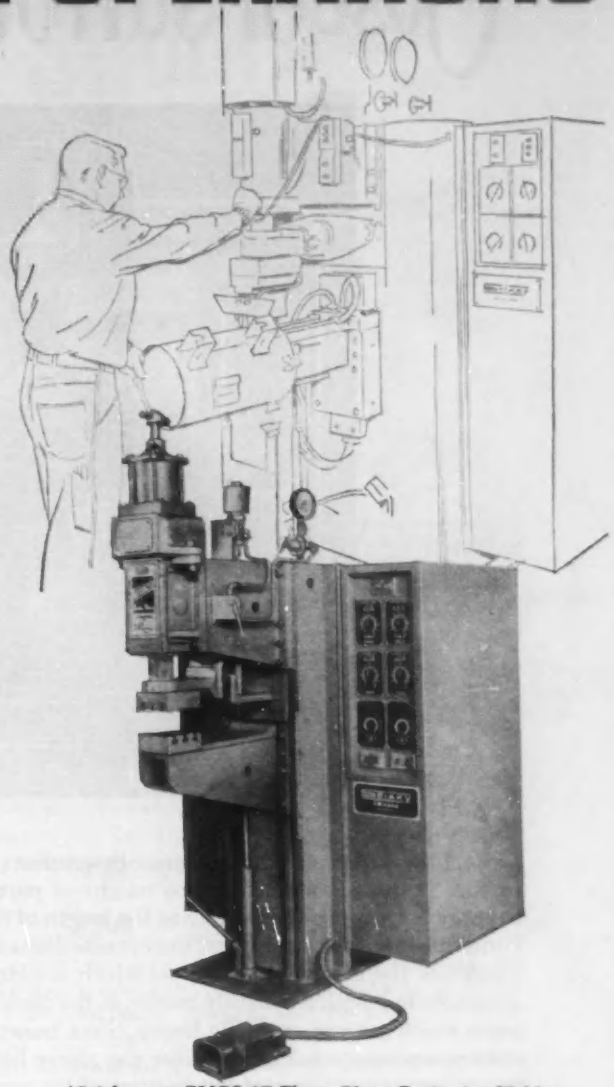
The background print shows clearly the intricacies and the close tolerances demanded by this part. Yet at Moraine it is produced *completely finished* after *one* press operation. Here's proof of what can be done through close cooperation between Moraine and customer.

The contributions of Moraine's metal powder process to industry are growing day by day. Complex designs like this are being produced by Moraine with great performance-improving, cost-cutting results for many customers.

m moraine products
DIVISION OF GENERAL MOTORS CORPORATION, DAYTON, OHIO

METAL POWDER PARTS

SEVEN DIFFERENT PRODUCTION OPERATIONS ON ONE STANDARD WELDER



Versatile Sciaky Standard Three-Phase Projection Welder Sharply Reduces Tooling Costs

With typical efficiency, Moloney Electric Company uses a minimum number of Sciaky machines for a maximum number of welding operations.

After careful study, Moloney found Sciaky electric resistance welding offered many advantages over other methods of fabrication. Sciaky patented Three-Phase principle of operation provided automatic compensation for variation in material thickness, piece-part configuration, and fit-up to improve weld quality and machine versatility.

Only Sciaky Three-Phase characteristics of balanced line load, high power factor, and 75% current reduction permitted such extensive use of resistance welding with existing power supply.

Now Moloney pressure-tight transformer tanks, from 10" to 30" in diameter, and 21" to 54" in height, are fabricated almost completely on Sciaky Three-Phase welders.

For complete details on the efficiency and economy of Sciaky resistance welding at Moloney, write for "Resistance Welding at Work", Volume 3, No. 7.

*Sciaky type PMCO 2T Three-Phase Projection Welder joins seven different parts to Moloney Transformer Tanks. A two-switch foot pedal provides immediate selection of preset heat and pressure sequences for different welds without removing tank from welder or stopping production to reset controls.

Largest Manufacturers of Electric Resistance Welding Machines in the World

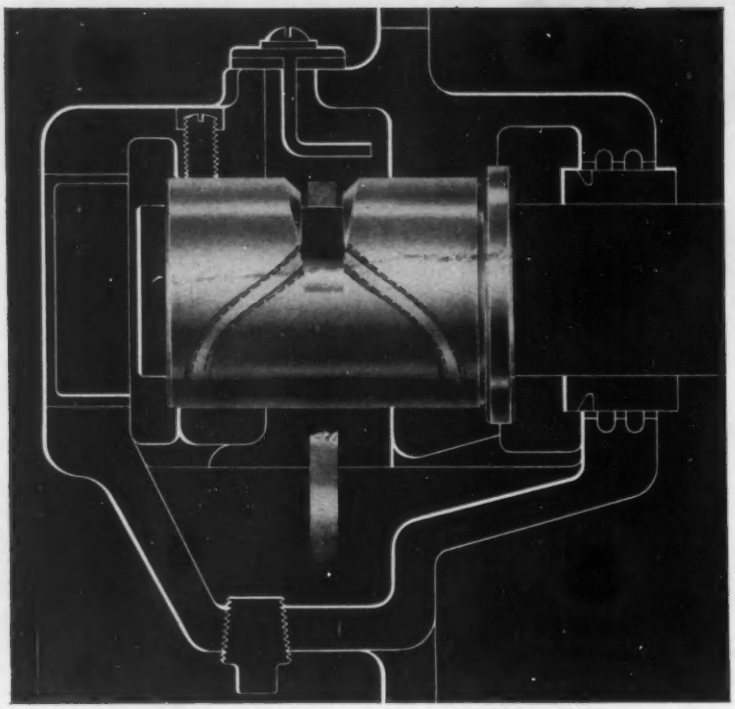
SCIAKY

4915 WEST 67th STREET, CHICAGO 38, ILLINOIS

Plants: Chicago • London • Paris Sales Offices: Chicago, Ill. • Buffalo, N. Y. • Cleveland, Ohio • Dayton, Ohio • Detroit, Mich. • Ft. Worth, Texas • Hollywood, Calif. • New York, N.Y. • Philadelphia, Pa. • Washington, D.C.

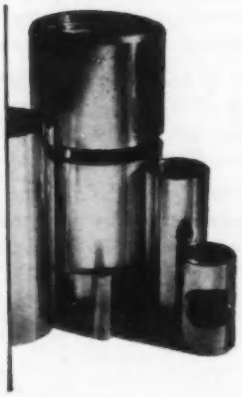
THE WAY TO CUT...

Cost of surrounding design



Although the sleeve bearing is longer than other types it is also much smaller in outside diameter. The weight of parts required to support bearings varies directly as the length of the bearing but it also varies directly as the *square* of the outside diameter of the bearing. Therefore the use of bearing types which are large in diameter and short in length frequently results in the use of surrounding parts which are unnecessarily heavy. Since unnecessary weight costs unnecessary dollars, consider the sleeve bearing not only for its own initial low cost but because of the possibility of reducing the weight and therefore the cost of the surrounding parts.

There is a Bunting Engineer near you. Consult him. Or send your inquiries direct to our Product Engineering Department at Toledo.



Bunting®

BRONZE BEARINGS • BUSHINGS • PRECISION BRONZE BARS

The Bunting Brass & Bronze Company • Toledo 1, Ohio • Branches in Principal Cities • Distributors Everywhere

WHEN YOU THINK OF SEAMLESS DRAWN
METAL STAMPINGS
THINK OF G. P. & F.
15 ACRES OF PRODUCTION FACILITIES • OVER 1000 SKILLED PEOPLE

You can end production headaches, increase manufacturing profits, and sell quality-built products, by using G. P. & F.'s complete fabricating and finishing service. Scores of America's leading firms use and recommend our service for hundreds of highly diversified items—including everything from parts for automobiles to home appliances—or from coin-operated dispensers to office equipment.

WE FINISH AND ASSEMBLE--- We can handle your *complete* job—from start to finish. We specialize in medium and large sized seamless drawn metal stampings—but our service also includes forming, welding, galvanizing, polishing, vitreous enameling, spray painting, and complete assembling.

ALL UNDER ONE ROOF----- Not only do we relieve you of production details and responsibilities, but we also increase your profits by reducing shipping time and transportation costs on your contracted parts. All work is done under one roof in our centrally located Milwaukee plant. And, if you wish, we can package your products, and ship directly to your customers!

G.P.&F.
SINCE 1880
MILWAUKEE

For complete details, without obligation, phone, write or wire Contract Division—

GEUDER, PAESCHKE & FREY CO.
1505 W. St. Paul Avenue
MILWAUKEE 1, WISCONSIN

SYNCHRON®
TIMING MOTOR

...reduce your real costs

...protect your profits

Frequent service calls caused by the use of short-lived motors can run *real* costs 'way up — cut a big slice from net profits — turn customers away.

If your product calls for trouble-free synchronous timing motors, you want the Hansen SYNCHRON. Users report up to 10 years continuous use without servicing, a record equalled by no other motor we know of.

"Work Horse of the Industry" since 1926

SYNCHRON Timing Motors start instantly, never need oiling, pull 8 in. oz. at 1 RPM in any position. They may be stalled continuously without injury, and are available with gear trains to convert any speed.

Advanced engineering, tested materials and precise manufacture under rigid inspection and quality control, assure long lasting dependability and accuracy.

Invitation to Designers

Get complete, concise engineering data showing how easily SYNCHRON Timing Motors, Timing Machines, and Clock Motors may be applied to mechanisms now in production or still in the idea stage.

You are invited to consult HANSEN engineers without obligation. Write or mail the coupon.

HANSEN MFG. CO., Inc., PRINCETON, IND.

Mail coupon for catalog, engineering data.

HANSEN MANUFACTURING CO., INC., Princeton 5, Ind.
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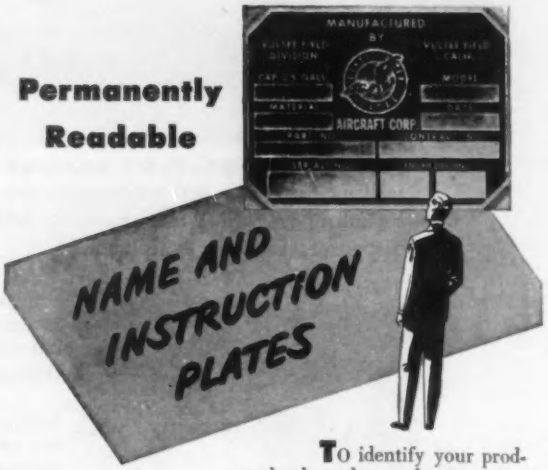
Imperial is known in drafting rooms all over the world as the traditional quality tracing cloth.

With the background of decades of experience, its makers have pioneered in modern improvements to maintain Imperial as the finest tracing cloth made.

Permanently Readable

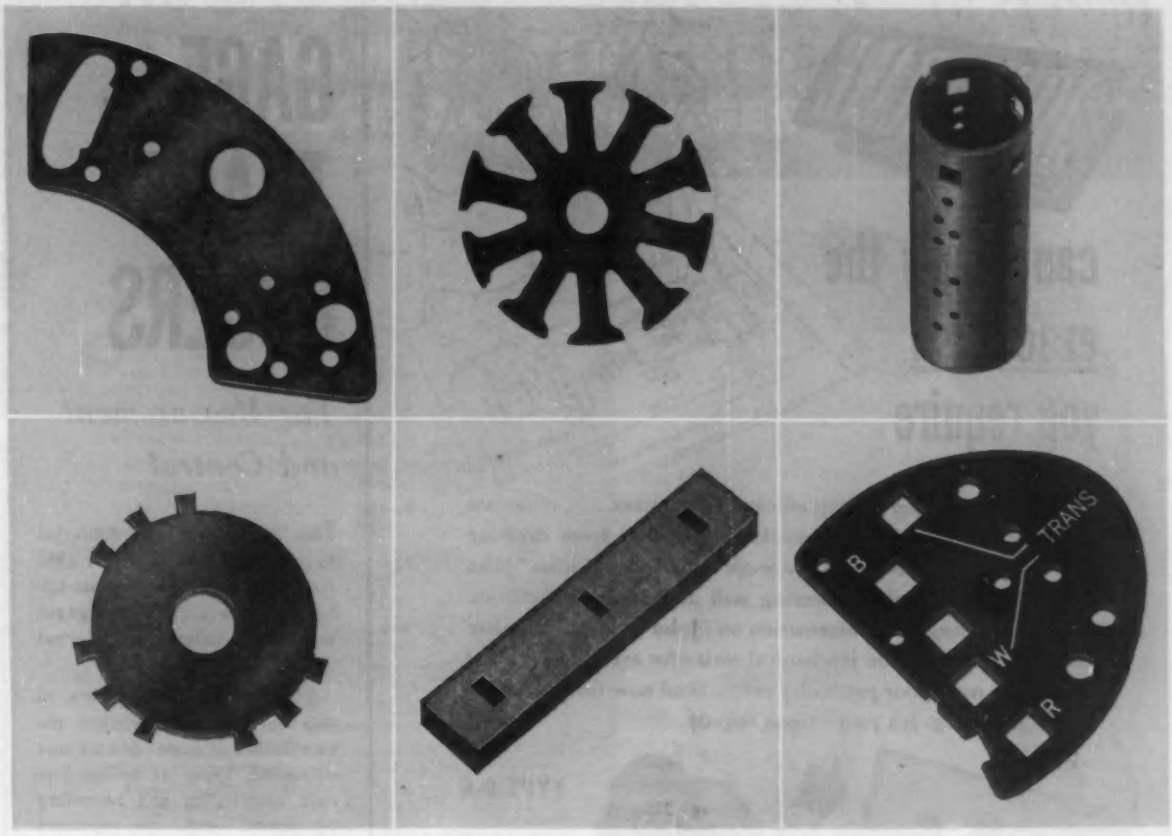


TO identify your product clearly and to make sure your instructions are permanently readable, use our high quality metal plates. We'll gladly help design plates that reflect your pride and match the quality of your product. Skilled craftsmen, modern equipment assure enduring satisfaction. Send rough sketch or blue print for design suggestion and quotation, without obligation.

Write for free book with full color examples of our plates.

CHICAGO THRIFT-ETCHING CORPORATION
1535 N. SHEFFIELD AVE., CHICAGO 22, ILL., DEPT. B
SUBSIDIARY OF DODGE MANUFACTURING CORPORATION, MISHAWAKA, INDIANA

Want to punch something?



THEN LOOK at these parts . . . all punched from Taylor Vulcanized Fibre or Laminated Plastics. They are typical of the wide variety of shapes and sizes that can be economically produced to close tolerances.

When you use Taylor Vulcanized Fibre and Laminates for your punched parts, you have a wide range of physical, electrical and mechanical properties to choose from. Vulcanized fibre can be furnished in sheets, rolls and rods . . . laminated plastics in sheets, tubes and rods. A variety of colors and finishes is available.

For switch insulation, brush holders, arc barriers, refrigerator latch gaskets, shielding, relay covers, armature slot insulation, luggage reinforcing strips, and washers . . . just to name a few applications . . . be sure and investigate the advantages of Taylor materials for making punched parts.

A Taylor Engineer will be glad to help you pick the grade of Vulcanized Fibre or Phenol, Melamine or Silicone Laminated Plastics that are best suited to your particular requirements.

Taylor Fibre Co., Norristown, Pennsylvania—La Verne, California.

TAYLOR
Laminated Plastics
Vulcanized Fibre

Remember!

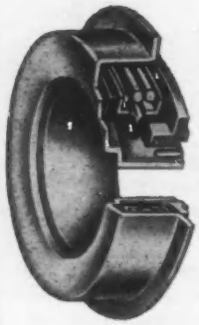
When you specify Mechanical Seals...

JOHN CRANE

can supply the exact seal you require

You can achieve the sealing efficiency you want . . . eliminate specification problems . . . work unhampered from drawing board to production—when you work hand-in-hand with "John Crane's" experienced engineering staff and available facilities.

Get quick, finger tip information on "John Crane's" complete line of high production mechanical seals—for every conceivable service—to meet your particular needs. Send now for illustrated technical catalog. It's your's upon request.

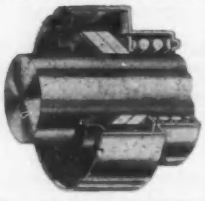


TYPE 6-A

Pressed-in packaged unit recommended for small shafts on hot or cold water, oil, gasoline or soapy liquids . . . pressures to 75 psi . . . temperatures from —65° F. to +220° F. Available in stainless steel or bronze.

TYPE 11-A

Pressed-in packaged unit with spring inside synthetic rubber bellows to protect against corrosion. For hot or cold water, oil, gasoline or soapy liquids . . . pressures to 35 psi . . . temperatures from —65° F. to +212° F.



TYPE 19

An all-purpose seal suitable for handling practically any liquid or gas, including highly corrosive acids and oils.

Low or high temperatures from —100° F. to +450° F. . . . pressures to 200 psi. Incorporates highly efficient sealing cones made of Du Pont's Teflon, which is inert to practically all chemicals.

Crane Packing Company, 1845 Cuyler Ave., Chicago 13, Illinois

JOHN CRANE **CRANE PACKING COMPANY**

STRAIN GAGE TRANS-DUCERS

For Measurement and Control

This 28-page Special Editorial Report from our November 1952 issue will give you the most up-to-date details on strain gages and this design tool's great versatility.

The first of five sections in this special report covers the two classes of gage—bonded and unbonded, types of bridge circuit, amplifying and recording equipment and the systems combining these components. The four remaining sections take up the different types of transducers designed specifically for measuring pressure, flow, weight and displacement. Case histories follow each transducer section to illustrate some of the more unusual applications for strain gage transducers.

Copies available at 35 cents each.

READER SERVICE DEPARTMENT

Product Engineering

McGraw-Hill Building
New York 36, N. Y.

ONLY FAWICK CLUTCHES GIVE YOU ALL THESE ADVANTAGES...

GET THESE OPERATING ADVANTAGES FOR YOUR MACHINES

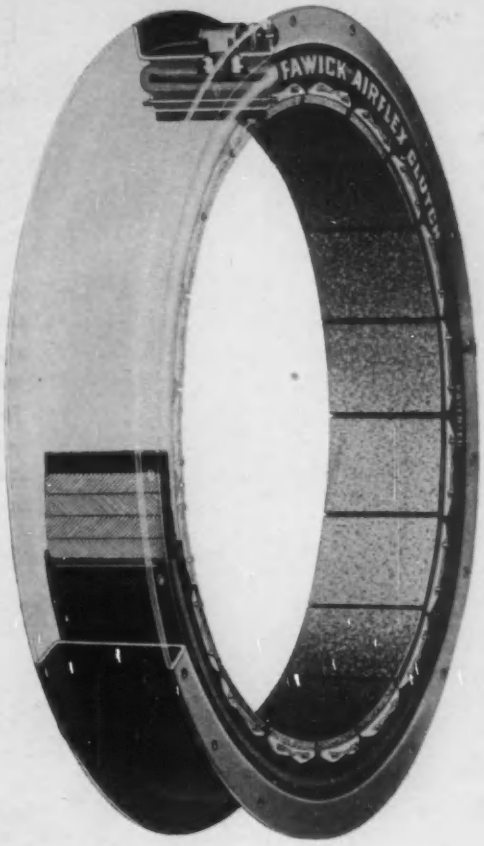
- **INSTANT FULL POWER WITH OVERLOAD PROTECTION**— The 360° friction contact with the full width of the drum plus the instant response to local or remote controls result in fast, full-power application with unmatched smoothness. Peak overload protection is assured at a selected air pressure.

- **LOW OPERATING WEAR WITH COOLER CLUTCH ACTION**— The FAWICK AIRFLEX CLUTCH design provides maximum clutch heat dissipation by thorough ventilation of the unit. FAWICK design provides complete separation of the friction shoes from the drum when the clutch is disengaged.

- **LOW MAINTENANCE**— FAWICK CLUTCHES require no lubrication or linkage adjustments. Their simple design and operation automatically compensate for wear of friction shoes.

- **CONTINUOUS NEW CLUTCH DEPENDABILITY AND PERFORMANCE**— The rugged, compact design of FAWICK AIRFLEX CLUTCHES plus their simple operating action and automatic adjustment for wear provide continuous and unmatched "new clutch" dependability and performance at all times.

FAWICK AIRFLEX DIVISION
FEDERAL FAWICK CORPORATION
9919 CLINTON ROAD • CLEVELAND 11, OHIO



FAWICK TYPE CB Airflex CLUTCH.

• *For further information on FAWICK Industrial Clutch and Brake Units write to the Main Office, Cleveland, Ohio for Bulletin 400-A.*

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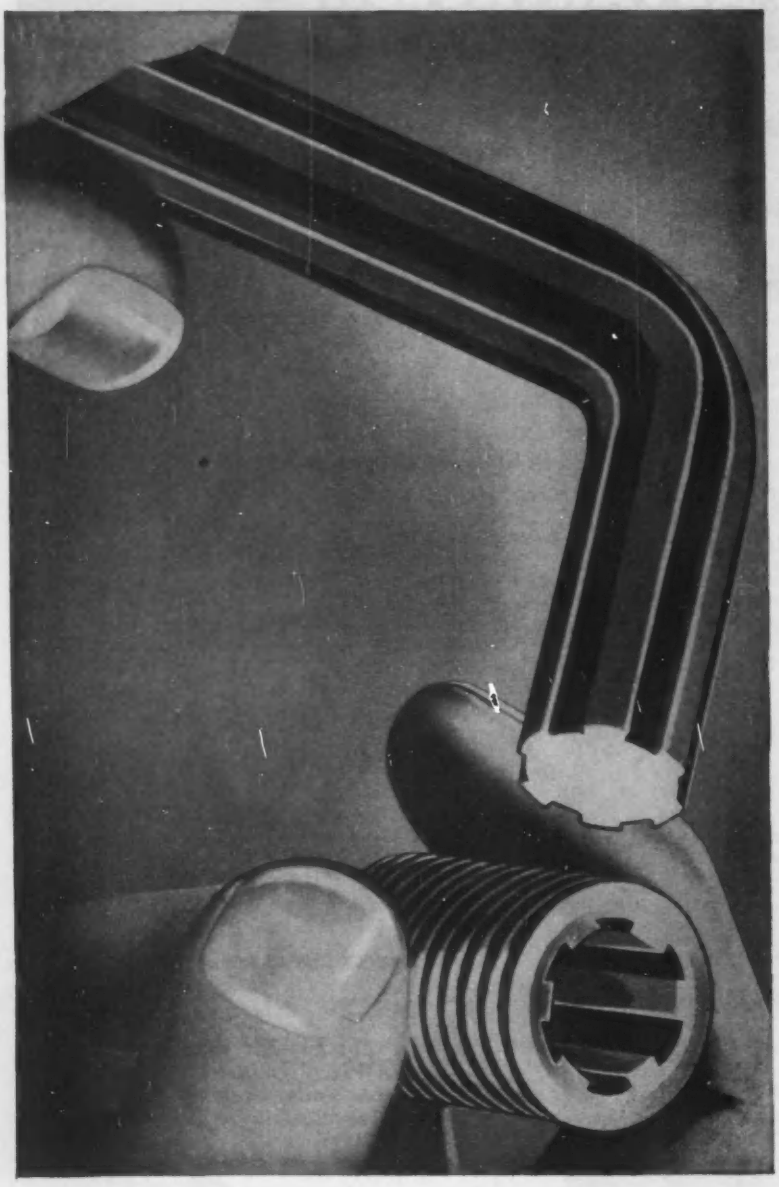
BRISTOL'S MULTIPLE-SPLINE SOCKET SET SCREWS

give far greater HOLDING POWER



The splining principle is recognized by design engineers as the most effective means of transmitting rotary power. That's why it's used in propeller hubs, drive shafts and automobile axles. In Bristol's Multiple-Spline Socket Set Screws, this design results in strength and holding power unequalled by any other screw.

Here are some of the features of Bristol's Multiple-Spline set screws that make them the choice of design, production and maintenance men everywhere . . .

- **greater holding power, permitting use of fewer, smaller screws**
- **easier, faster, and tighter setting**
- **ability to withstand severe shock and vibration**
- **no rounding-out, splitting or breaking under internal wrenching**
- **tamper-proof**

There's no delivery problem with Bristol's Multiple-Spline Socket Set Screws, either. In sizes ranging from No. 2 wire size to ⅜ inch, all of Bristol's screws are precision-made to conform to Class 3 fit.

Write today for your free copy of Bristol's 40-page catalog on socket screws.

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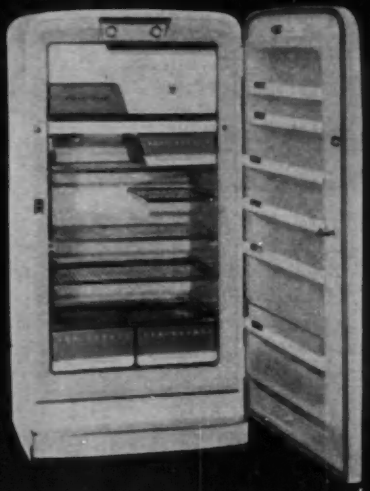
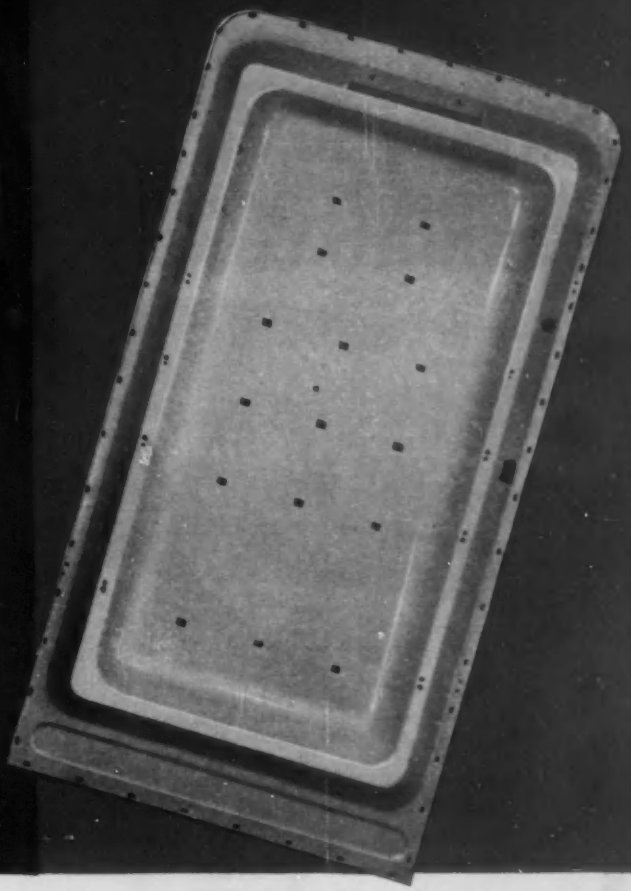
BRISTOL'S SOCKET SCREWS

THE BRISTOL COMPANY, Socket Screw Division, Waterbury 20, Conn.

Largest area ever molded!





General American's 1800 square inch inner door panel for the new 1953 WESTINGHOUSE 12FT. REFRIGERATOR

SIZE: Approximately 1800 sq. inches (39¾" h. x 32" w.)
MATERIAL: High-impact polystyrene
MOLDING: performed on one of General American's battery of 300-ton injection presses

NEW SALES FEATURES:

Unexcelled luster and appearance
Very easy to clean
Does not absorb odors
Color all the way through
Chip and crack resistant
Permits deeper shelves
Increases cubic content
Strong and dimensionally stable

Not very long ago, engineers would have said, "You can't do it! Too big! Too difficult!" But as in so many cases with plastics, none of the objections held up. Good creative engineering, thorough understanding of materials and large production equipment enabled General American and Westinghouse engineers to do the job.

The result: A panel so sturdy that it is a structural member of the door. Rounded contours which permit flexible shelf arrangement. Many new sales and production features—*another good example of precision molding by General American to back up industry's production lines.*

General American's facilities and experience in molding injection, compression and reinforced plastics may hold the answer to your production needs, too. Why not find out?

Member, Committee on Large Plastics Molding

plastics division
GENERAL AMERICAN TRANSPORTATION CORPORATION
135 South La Salle Street, Chicago 90, Illinois
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Bendix-Skinner

RIBBON FILTER ELEMENTS . . .

- LOWER ORIGINAL COST
- SIMPLE, INEXPENSIVE TO INSTALL
- NO EXPENSIVE BACK UP SUPPORT REQUIRED
- PERMANENT TYPE
- HIGH FLOW RATE (EITHER DIRECTION)
- EASILY CLEANED

It seems hard to believe, but you can actually have more efficient filtration at considerably lower cost if you simply use Bendix-Skinner ribbon elements instead of expensive and less adaptable metal edge or metal screen types.

Here's how it works— Bendix-Skinner ribbon elements are inexpensive to begin with and can be installed at far less cost than metallic elements that require special back up supports. In fact, in practically every instance present metallic-type elements can be changed over to ribbon-type with substantial savings.

Ribbon units are available in diameters from ½" to 6" in any required length with filtration rated at 40 microns (.0016").

Our engineering department will be glad to advise on new installations or to furnish replacement units in a variety of sizes. Write us for details.

Performance proven in millions of installations.

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ORIGINATOR OF **MICRONIC** FILTRATION

BENDIX-SKINNER DIVISION OF Bendix

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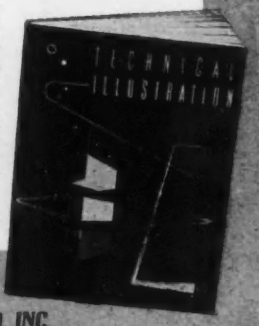

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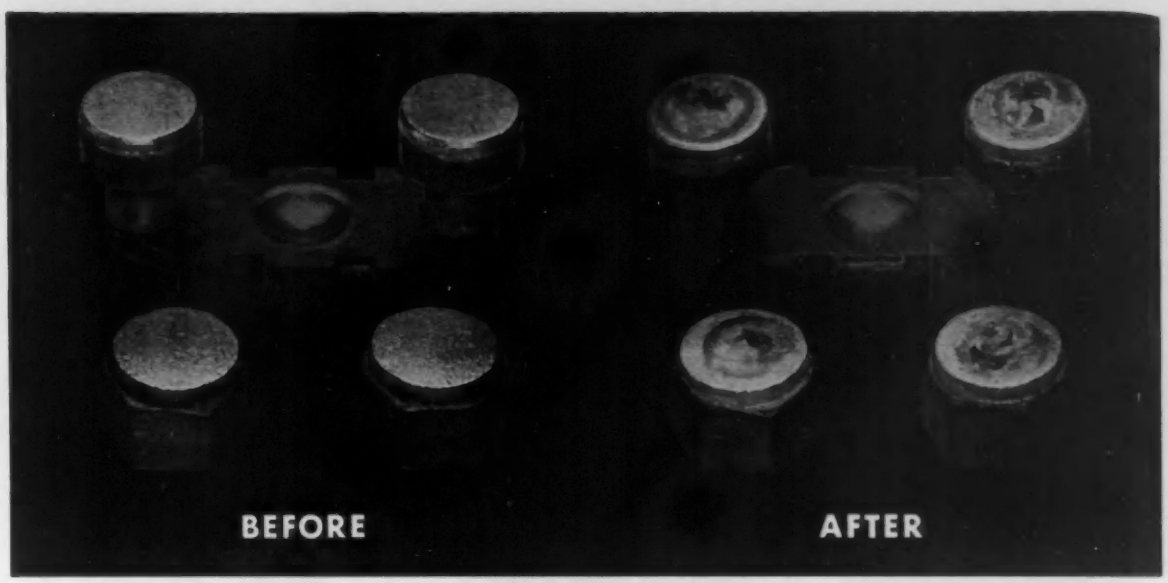


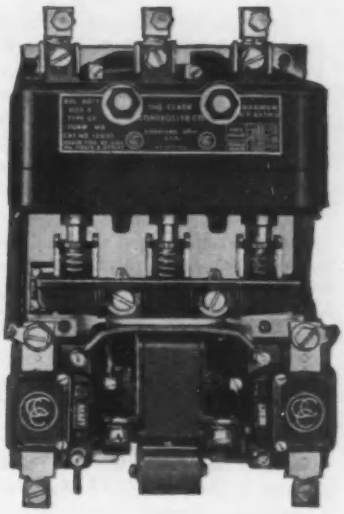
PROOF OF LOW MAINTENANCE ON CLARK TYPE "CY" STARTERS

These unretouched photos show contact tips from a CLARK Bulletin 7707 contactor—the contactor used in the standard Bulletin 6013 size 2 AC Motor Starter — as they looked before and after a year of hard use.

The contactor is in service at Cleveland Hone and Manufacturing Company, on a special transformer and rectifier circuit used in processing automotive parts. The tips shown right above were removed from the contactor after 12 months of steady service, often operating as frequently as 5000 times per hour.

Note that slight discoloration and minute pitting are the only evidence of wear. They require no cleaning, dressing or filing, and are in condition to give many more years of dependable service.

The secret of long contact life in the CLARK Type "CY" Starter is its exclusive arc-quenching principle, using strong multi-turn magnetic blowouts and double-break contacts. Forced rotation causes the arc to move continually on the contact surfaces, distributing the heat and preventing pitting or "build-up" at any one point. Result: extremely effective arc interruption, and greatly reduced wear on tips.



CLARK Type "CY" Starters include many more features for dependable service and reduced maintenance. Let us tell you the complete story.

Write for descriptive literature.

THE CLARK CONTROLLER CO.

ENGINEERED ELECTRICAL CONTROL • 1146 EAST 152ND STREET, CLEVELAND 10, OHIO

rotary multipole switch

ESCO TYPE-A

The ESCO Type-A Rotary Switch is a compact, multipole switch for tap, transfer, and selector service.

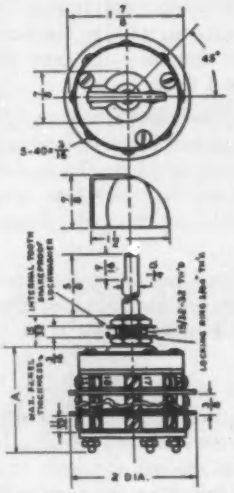
It can be furnished for continuous rotation, in both directions, through eight positions, or can be provided with movement limited to from two to eight positions. An important advantage of the Type-A switch is that it has an exceptionally sturdy detent mechanism that assures positive positioning of the switching elements at all eight positions.

Movable contacts carried on molded-phenolic rotors engage fixed contacts distributed around the circumference of recessed, molded-phenolic disks so constructed that the make and break action is wholly contained within an insulating enclosure. Assemblages of fixed and movable contacts to suit varied switching needs can be combined so that as many as seven different sections can be controlled by a single knob.

ELECTRICAL RATINGS — TYPE-A SWITCH

Service		Amperes	Volts
Continuous current		10 a-c/d-c	125
Interrupting	0.75 p. f. lamp load	5 a-c	125
		3 a-c	125
	non-inductive	5 d-c	30
		1 d-c	125

Heavy-duty rotary switches rated at 10, 30, 60, 100, or 200 amperes are also available from ESCO. Bulletins giving detailed specifications on all ESCO switches will be furnished on request.



SECTIONS	DIM. A	APPROX. WEIGHTS
1	1 1/16	3 oz.
2	1 7/16	4 oz.
3	1 13/16	5 oz.
4	2 3/16	6 oz.
5	2 9/16	7 oz.
6	2 15/16	8 oz.
7	3 5/16	9 oz.

ELECTRO SWITCH
CORPORATION
167 King Avenue, Weymouth 88, Mass

High Speed

PHOTOGRAPHY IN DESIGN

High-speed photography not only offers the designer all of the advantages generally associated with ordinary stills and moving pictures, but also puts at his disposal a means for actually studying motions and events that until recently have never been "stopped" or slowed down to perceptible speeds.

Product Engineering's Special Editorial report on this subject gives designers a thorough study of basic considerations in the field of high-speed photography, operation and characteristics of major types of high-speed cameras, and some typical fields of application.

Included with this report is a fully illustrated Chart of High-Speed Camera Systems, headed by a master diagram that shows the essential elements of high-speed camera optical systems.

Reprints (including chart) available at 35c per copy

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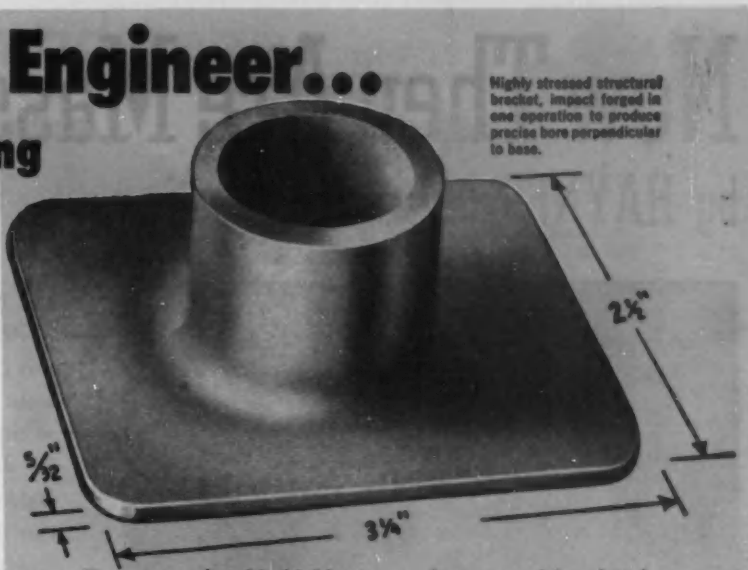
Mr. Design Engineer...

do a little exploring



Highly stressed structural bracket, impact forged in one operation to produce precise bore perpendicular to base.

You can make this highly stressed structural bracket by:

1 Machining from a typical forging

Metal waste	—High
Machining cost	—High
Physical properties	—High
Material cost	—High

2 Machining from a casting

Metal waste	—High
Machining cost	—High
Physical Properties	—Low
Material cost	—Low

3 Hogging from bar stock

Metal waste	—High
Machining cost	—High
Physical properties	—Fair
Material cost	—High

4 Hunter Douglas Impact Forging

Metal waste	—Low
Machining cost	—Low
Physical properties	—High
Material cost	—Low

Every method offers an advantage, but Impact Forging offers every advantage.

Discover the advantages of

IMPACT FORGING

FROM

HIGH STRENGTH ALUMINUM ALLOYS

IMPACT FORGING is a new technique perfected by Hunter Douglas to mass produce heat-treatable aluminum alloy parts with close dimensional tolerances and forged grain flow. Impact Forging forces the material to the desired shape by direct compression with little metal waste. Many times the part is impact forged to final print in one operation, eliminating any secondary machining operations.

Impact Forging offers you variable side walls, zero draft, and close dimensional tolerances in a variety of tubular, rectangular, and symmetrical shapes. The economic advantages of Hunter Douglas Impact Forging can be best realized if you are designing a part for production in quantities of 1 thousand to 1 million a month. Impact Forging gives close dimensional tolerances, micro-precise surface finish, and the high physical properties of a forging. Spark your imagination and improve your position in the competitive field by investigating the advantages of Hunter Douglas Impact Forging.

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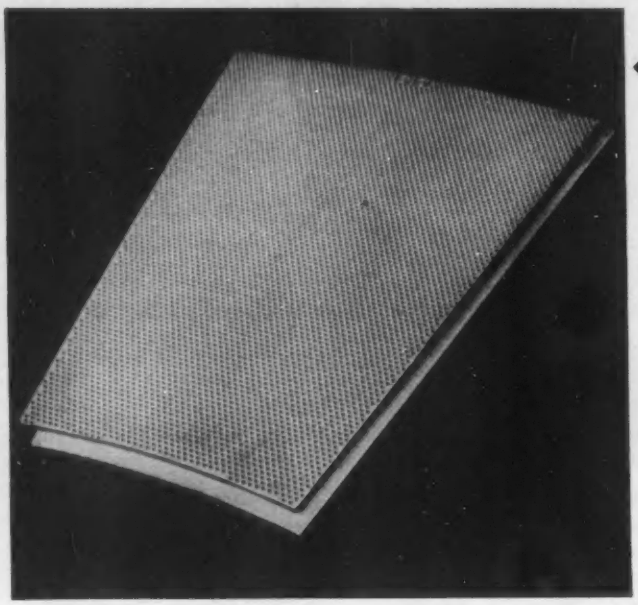
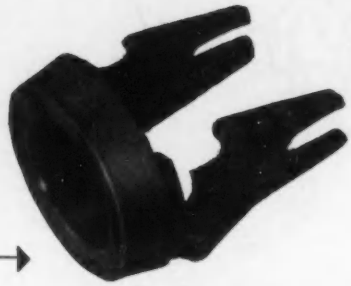
by HAYNES Investment Casting

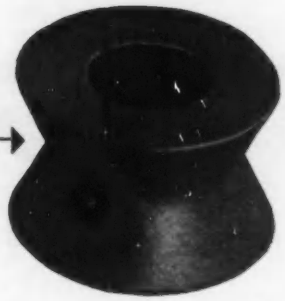
Trade-Mark



IMPROVED DESIGN AND MATERIAL—The tiny needle-sharp points covering this plate must resist severe abrasion. Machined points used to wear out frequently because they were pyramidal in shape and highly susceptible to erosion. HAYNES investment casting made it possible to cast the points in a more stable conical shape from a hard, wear-resistant alloy. Life has been increased by 5 to 12 times.



EXCELLENT SURFACE QUALITY—For sanitary reasons, not even the smallest crevice can be tolerated on this cream separator part. Because of the high quality of HAYNES investment castings, it was found that the intricate part could be manufactured on a production basis with a minimum of imperfections showing up during the final polishing operations. This eliminated a great deal of wasted time, work, and metal.



NO MORE MACHINING—HAYNES investment casting eliminated the job of machining these rollers. Service conditions require that the rollers be made of a special alloy which is difficult to machine. They must resist rusting and the cutting action of wire passing over them under tension. The rollers give excellent service life and there are no more machining problems.

HAYNES investment castings can solve some of your own production and design problems. For more information, contact the nearest Haynes Stellite Company office listed below.

"Haynes" is a registered trade-mark of Union Carbide and Carbon Corporation.

HAYNES INVESTMENT CASTINGS

Trade-Mark

Sound, dense, high-strength parts available in cobalt-base alloys, nickel-base alloys, iron-base alloys, stainless steels, and alloy and carbon steels.

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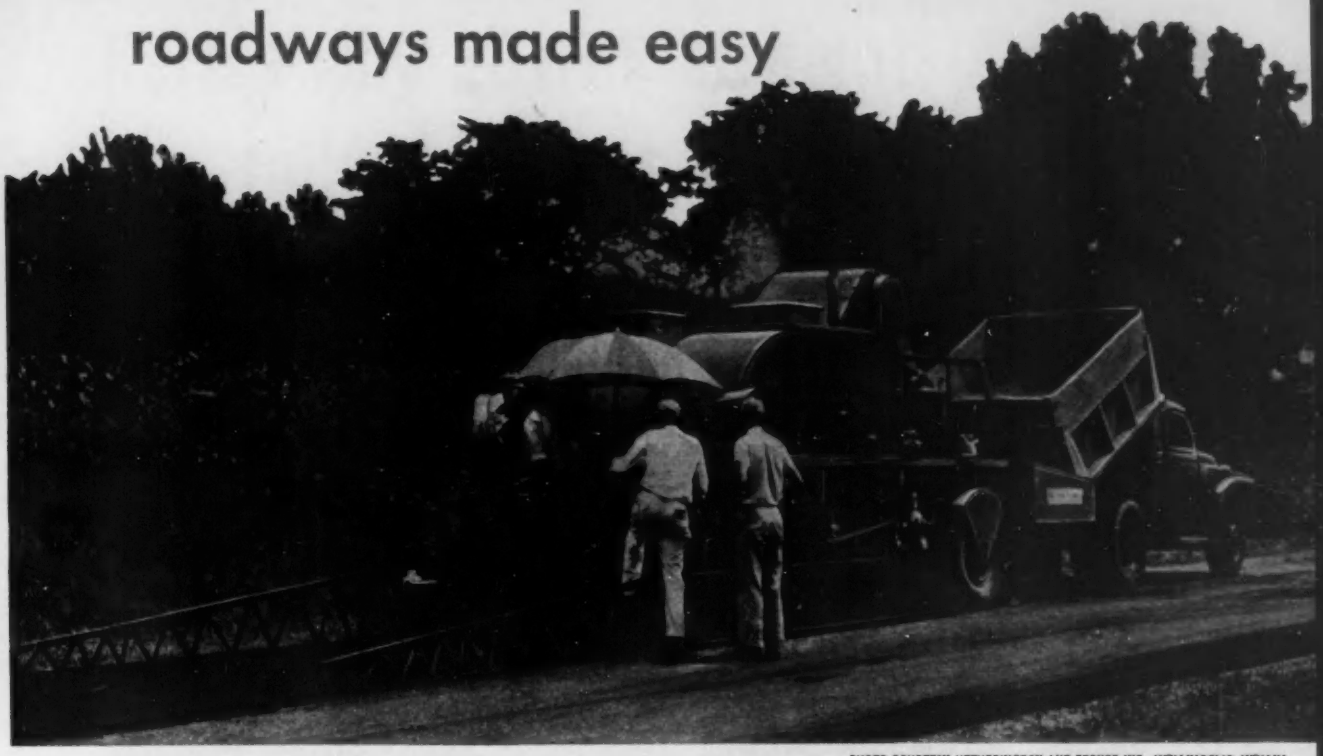

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Chrysler *Power helps keep America rolling... at less cost*

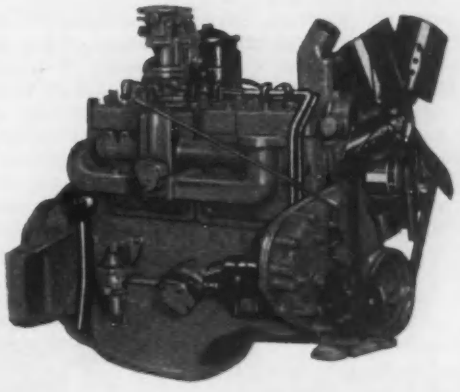
This mobile mixer-paver replaces costly man-hours with economical horsepower. In one continuous operation the unit takes in sand, gravel, stone or other road surfacing materials, mixes them in with a binder ingredient—all in predetermined proportions—and spreads the mixture onto the roadbed, to whatever depth best meets grade and crown requirements. Materials to be mixed may be fed to the unit from trucks, as in this case, or picked up from windrows with a loader attachment. The entire operation requires the services of three, possibly four, men.

The Hetherington and Berner Moto-Paver turns out up to 120 tons of mix per hour for resurfacing jobs. Paving width is adjustable from 8½ to 12 feet, depths to 7 inches. Paving speeds start at two feet per minute. Road speeds up to twenty-five miles per hour enable the equipment to carry itself from one job to another.

Two Chrysler Industrial Engines power this equipment. Travel components are driven by our Model 8 Engine whose 250 cubic inch displacement, together with Chrysler gyrol Fluid Coupling, provides power with flexibility of operation. A Model 14, powerful 331 cubic inch displacement engine, drives mixer, conveyor, spreader and pumps.

If your equipment requires power within our 230 to 413 cubic inch displacement range, engines that will operate equally well on gasoline, natural or L-P gas fuels, engines ideally suited to power take-off, see a Chrysler Industrial Engine Dealer. He can *power-fit your equipment for best performance in the field.*

Remember, too, that Chrysler Power is not expensive. Production-line methods adapted to specialized industrial engine building provide a custom-built engine at mass-production prices. If you prefer, write: ***Department 52, Industrial Engine Division, Trenton, Michigan.***



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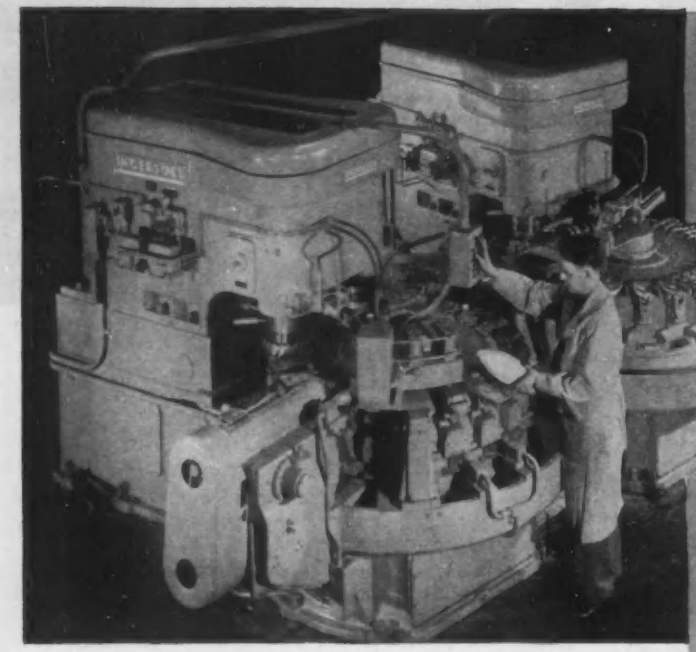
SNAP-LOCK TRADE MARK plays a vital part in new plant-automation plans



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Snap-Lock is the heavy duty limit switch—quick acting, positive, dependable—built *by* machine tool builders *for* machine tool builders.

In the 15 years since we first designed Snap-Lock to meet our own machine tool needs, it has been adopted as the standard switch equipment by 4 out of 5 of all builders of precision operated machine tools. Hundreds of users of other types of equipment also specify Snap-Locks—where control is vital, where lasting and service-free life is more important than mere price.

If you have a switch problem, choose from the wide variety of Snap-Lock standard types with regular or special mountings or, if you need a special application, let our engineers help you design Snap-Lock into your product.

Ask for Engineering Bulletin EM-51

INGERSOLL says:

"For this special model, again we rely on 13 Snap-Lock switches to insure correct sequencing of all 6 operations for automatic milling of tops, bottoms and sides of sole plates for electric flat irons at 1000 per hour-- fastest rate ever attained."

The Ingersoll Milling Machine Co. at Rockford, Ill., top flight builders of precision automatic milling, boring and drilling machines, have for years standardized on Snap-Lock limit switches.

ELECTRICAL MANUFACTURING DIVISION

The NATIONAL ACME COMPANY

170 EAST 131st STREET • CLEVELAND 8, OHIO

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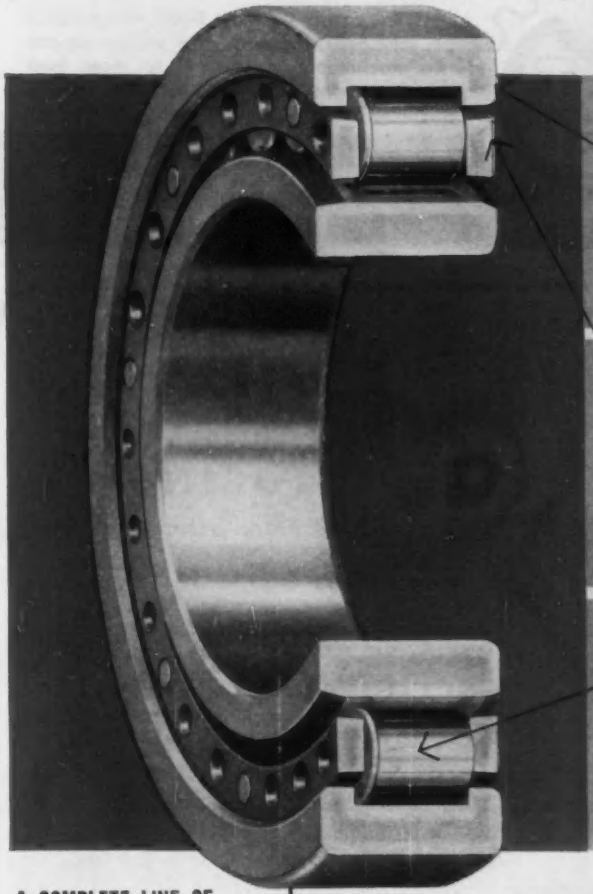
Here's why BOWER straight roller bearings can carry maximum loads—with less maintenance!

The important design features of Bower straight roller bearings shown on this page are just a few of the reasons why these bearings will operate efficiently and economically in your product. Consider these facts, too. Bower straight roller bearings incorporate highest quality materials and workmanship. They have proved themselves capable of standing up day in and day out under maximum loads—with little or no maintenance.

In fact, this is the reason why Bower straight roller bearings are used extensively by leading manufacturers in such fields as automotive, earthmoving, farm equipment and machine tool.

Let a Bower engineer give you full details of the complete Bower line. Call him in while your product is still in the blueprint stage.

BOWER ROLLER BEARING COMPANY • DETROIT 14, MICHIGAN



● ***TWO-LIP RACE INCREASES RIGIDITY.*** These two shoulders, made parallel, are integral with the outer race. This provides a more rigid, durable construction. Rollers are kept in proper alignment at all times.

● ***COMPOSITE STEEL CAGE DOES NOT CONTACT ROLLERS DURING NORMAL OPERATION,*** thereby allowing free movement of the rollers between the races. Projections on the inner faces of the rings engage indentations on the roller ends preventing the rollers from dropping out of position when the separable race is removed.

● ***PRECISION-BUILT ROLLERS AND RACES ARE MADE TO SUPPORT MAXIMUM RADIAL LOADS.*** Only the highest grade steel-alloy is used, and rollers and races are precision ground to give quieter, smoother operation. Running clearance is built in at the time of manufacture.

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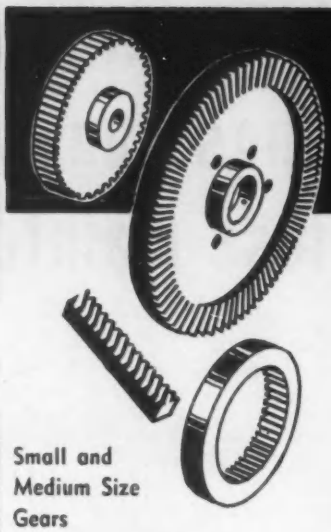

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PRECISION GEARS *for YOUR individual requirements.....*

produced promptly to specifications

The "Mass Gear" organization specializes in gear design and production. Its facilities can be *your* Gear Department, making it unnecessary for you to equip your shop with special gear-production machinery. You'll find it highly economical and most satisfactory to place your requirements in the hands of "Mass Gear".

You specify—"Mass Gear" will produce the gear, the worm, the pinion—in any machinable material — to meet your conditions of application and service.

G&T C

Massachusetts Gear & Tool Co.
WOBURN, MASS.

SILVER LAMINATED TUBING

for manufacturers of

POTENTIOMETERS, SLIP RINGS

and other users of materials for

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Maximum Diameter 1" x 060 Wall

TOLERANCES: + .000 — .001 on O. D.; + .001 — .000 on I. D.

All Items Custom-Made in a Variety of Metals
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The Home of IMPROVED Service
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The IMPROVED SEAMLESS WIRE COMPANY
INCORPORATED 1899
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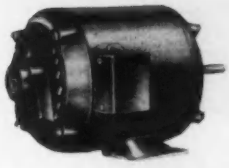
TO GET ALL THE PERFORMANCE DESIGNED INTO YOUR PRODUCT

Choose Century MOTORS

From the Wide Range of Types of ... in Sizes From 1/8 to 400 Horsepower



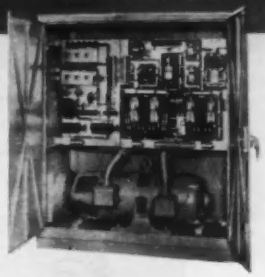
SINGLE PHASE:

Split Phase Induction—⅛, ¼, ⅓ H.P.

Capacitor—⅛ to 20 H.P.
Repulsion start, brush lifting, induction—½ to 7½ H.P.

Write for Bulletin Nos.:

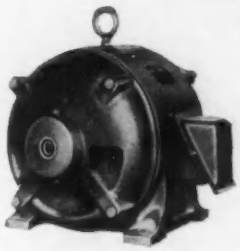
Split Phase 1-5P1
Capacitor 1-1P3
Repulsion Start 2-1P1



SELECTIVE SPEED DRIVE:

A complete line of adjustable speed drives for coordinating all kinds of production processes.

Write for Bulletin No. 11-1P1



POLYPHASE:

Squirrel Cage Induction—⅛ to 400 H.P.

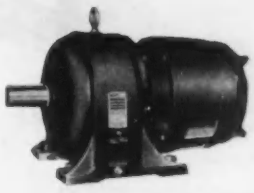
Wound Rotor Motors—1 to 400 H.P.

Synchronous Motors—20 to 150 H.P.

Write for Bulletin Nos.:

Squirrel Cage, Drip Proof—6-1P1
Squirrel Cage, Splash Proof—6-1P3
Squirrel Cage, Enclosed Fan Cooled—6-1P41
Squirrel Cage, Explosion Proof—6-1P45
Wound Rotor—6-3P1

GEAR MOTORS:



⅛ to 15 H.P., single, double and triple gear reduction.

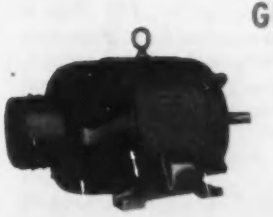
Write for Bulletin Nos.:

⅛ to ¾ H.P. . 4-5P21-61
1 to 15 H.P. . . 4-1P31

DIRECT CURRENT:

All capacities—⅛ to 300 H.P.
Write for Bulletin No. 10-1P1

GENERATORS:



AC, .63 to 250 KVA
DC, .75 to 200 KW

Write for Bulletin Nos.:

AC, .63 to 250 KVA—18-1P21
DC, .75 to 200 KW—18-1P1

82388

Motors listed above are available in Open Rated Drip Proof, Splash Proof, Totally Enclosed Fan Cooled and Explosion Proof frames—and with a dozen different methods of mounting. They are unusually quiet starting and running and unusually free from vibration.

Send the Coupon for Additional Facts

To CENTURY ELECTRIC COMPANY
1806 Pine Street, St. Louis 3, Mo.

Please send me the following bulletins:
(fill in numbers here) .....

Name ..... Title .....
Company .....
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City ..... Zone ..... State .....

Century Motors

CENTURY ELECTRIC COMPANY
1806 Pine Street, St. Louis 3, Missouri
Offices and Stock Points in Principal Cities

Vibration testing made easier

Electronic component under test at Eclipse-Pioneer division of Bendix Aviation Corporation.

with the help of MB equipment like this

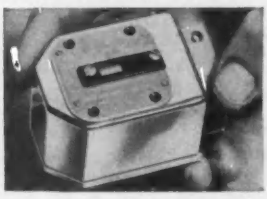
Do you have to vibration-test your product to meet military specifications? Want to apply shake-testing to improve product design or to control quality? If so, do what many leading companies have done—enlist the help of MB.

First, you get the right equipment. MB offers a *complete* line of vibration exciters from 10 pounds force all the way to the largest developed today—10,000 pounds! All are quality built to stand up and do the job right to specifications. Electromagnetic in operation, they're easily and quickly adjusted for force and frequency. And, second, you get the benefit of MB's wide experience in applying this relatively new and valuable technique for product improvement.

Among the well known companies working with MB products, Bendix Aviation Corporation's Eclipse-Pioneer division is outstandingly equipped with *several* MB Vibration Exciters. The photograph shows one—MB Model C-25, rated at 2500 pounds of force—vibrating an electronic component to insure dependability under severest conditions. Such testing can uncover, in minutes, trouble that might take months to develop.

VIBRATION PICKUP ANOTHER USEFUL TESTING TOOL

When you want to detect vibration and determine its nature, you'll want an MB Vibration Pickup. While the pickup detects even slightest vibratory motion, it was built for grueling service as well. Model 122 withstands temperatures up to 500°F.



Control panels for all MB shakers, as in the photo above, can be furnished with MB Vibration Meter for use with pickup. This meter gives direct velocity, acceleration and amplitudes of the picked-up vibration.

Bulletins you'll welcome

How to calibrate vibration pickups to 2000 cps—Bulletin C-11-6 reviews the subject comprehensively. Bulletin 1-VE-6 tells all about MB Vibration Exciters. Write for them.

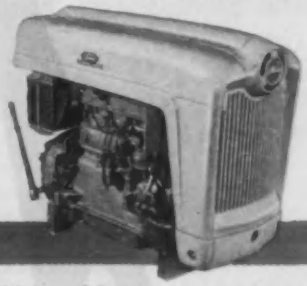
THE MB MANUFACTURING COMPANY, INC.
1060 State Street, New Haven 11, Conn.

HEADQUARTERS FOR PRODUCTS TO INDUCE VIBRATION...TO MEASURE IT...TO ISOLATE IT

Here's Big News!

FORD'S LATEST "172" CU. IN. ENGINE

★ OVERHEAD-VALVE
★ LARGE BORE
★ SHORT-STROKE
★ DEEP RIGID BLOCK



Pictured here are two types of sheet metal available with this Ford "172" 4-Cyl. Power Unit. Either type can also be specified with the Ford "134" 4-Cyl. Power Unit.

Ford
INDUSTRIAL ENGINES
AND POWER UNITS

Here is another Ford power plant of the most modern large bore, short-stroke, low-friction design . . . engineered, built and tested *exclusively* for *industrial* applications!

This new Ford engine delivers the mightiest concentration of power *per cubic inch* of any engine of comparable size and weight. With only 172 cu. in. displacement, this 4-cylinder engine attains a maximum of 58 brake horsepower at 2400 rpm. Less displacement normally requires less gas which means greater daily operating economy. Other outstanding features of this new Ford "172" Heavy Duty Industrial Engine are listed below.

Glance through them now and don't hesitate to ask or write for a detailed folder with complete specifications or any other information on the latest in engine design. *Write to:*

INDUSTRIAL ENGINE DEPARTMENT
FORD MOTOR COMPANY
15050 Woodward Avenue, Highland Park 3, Michigan

Features that Provide Highest Performance and Outstanding Economy

Large bore (3.90 in.) combined with *short stroke* (3.60) cuts piston travel, reduces friction, delivers more power at clutch and reduces fuel costs.

Deep-skirted crankcase is a feature that provides high structural rigidity for more efficient operation and longer life.

Precision-molded alloy iron crankshaft, fully counter-balanced in motion with mirror-like bearing surfaces that reduce friction to a minimum.

Free-turn valves (intake and exhaust) for even wear to help maintain high compression for longer than average period and reduce the possibility of valve sticking.

Weather-proofed ignition provides molded rubber integral seals for all spark plug terminals and lead wires. Distributor also tightly sealed against dust and dampness.

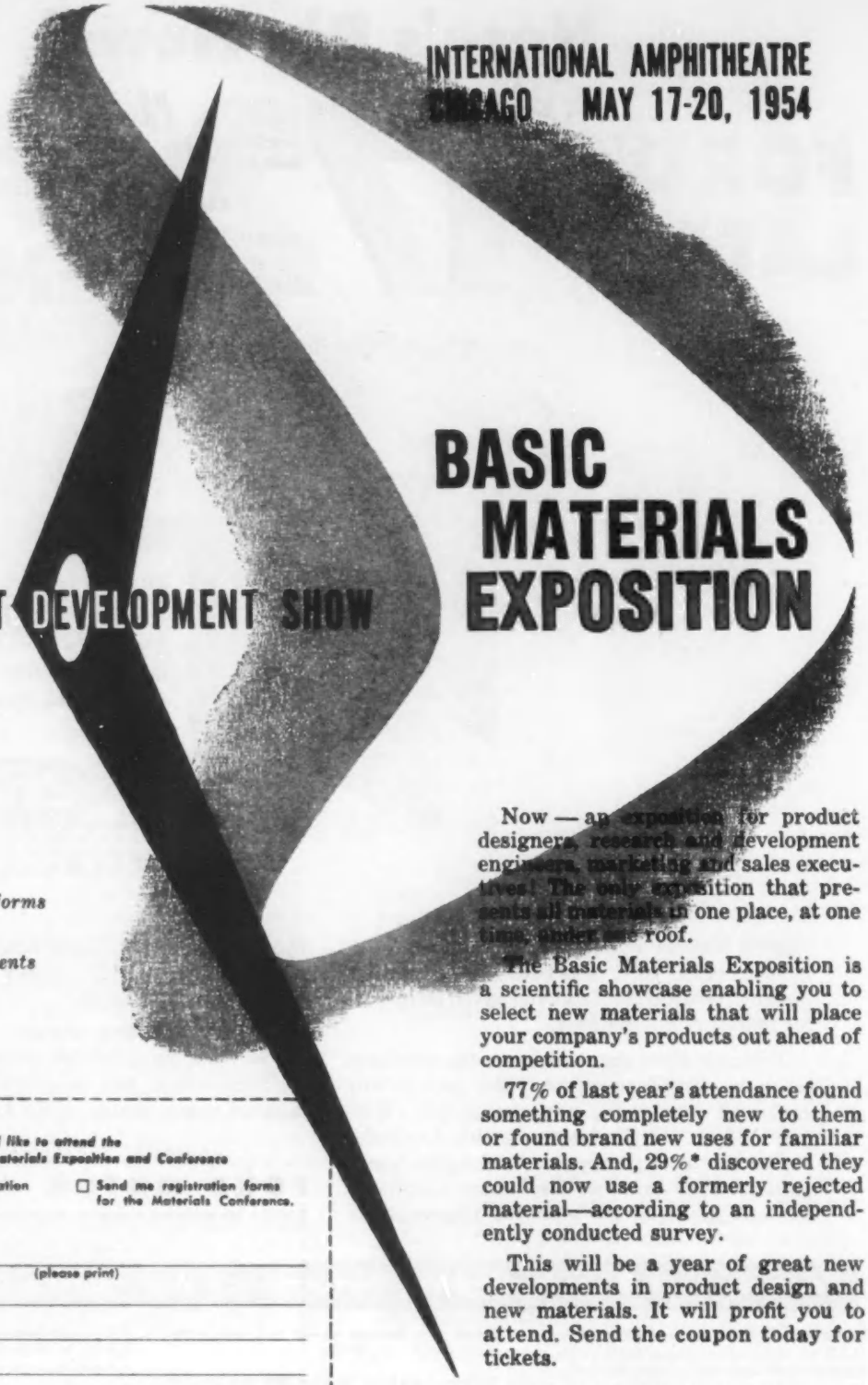
Full-flow oil filter with full-pressure lubrication contributes to longer engine life.

Autothermic pistons of cam-ground aluminum alloy with steel struts for controlled piston-to-sleeve clearance.

Full-length water jackets surrounding each cylinder to maintain uniform temperature, which in turn minimizes bore distortion and reduces wear.

Fast-acting, fully lubricated, variable speed governor is mounted on crankshaft as an integral part of engine.

Every Ford Industrial Engine from 134 cu. in. to 317 cu. in. is a complete, precision-built "Power Package," delivered fully equipped, tested and ready-to-run. All are available as Engine Assemblies or Complete Power Units with a wide variety of accessories and adaptations to fit your job.



Metals

Alloys

Plastics

THE PRODUCT DEVELOPMENT SHOW

Non-metallic materials

Coatings

Finishes

Fabricated parts and forms

Basic product components

Now — an exposition for product designers, research and development engineers, marketing and sales executives! The only exposition that presents all materials in one place, at one time, under one roof.

The Basic Materials Exposition is a scientific showcase enabling you to select new materials that will place your company's products out ahead of competition.

77% of last year's attendance found something completely new to them or found brand new uses for familiar materials. And, 29%* discovered they could now use a formerly rejected material—according to an independently conducted survey.

This will be a year of great new developments in product design and new materials. It will profit you to attend. Send the coupon today for tickets.

* Totals more than 100%, because respondents answered more than one question.

Basic Materials Conference

Held concurrently with the Exposition. Led by T. C. Dumond, editor of Materials and Methods. Covers new applications of materials.

Yes! I would like to attend the Basic Materials Exposition and Conference

☐ Send me expedited registration tickets for the Exposition. No registration fee.

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Mail To: Dept. C-3 CLAPP & POLIAK, Inc.
Show Management
341 Madison Ave., New York 17, N. Y.

A TIGHT SEAL WITH A BALANCED LOAD

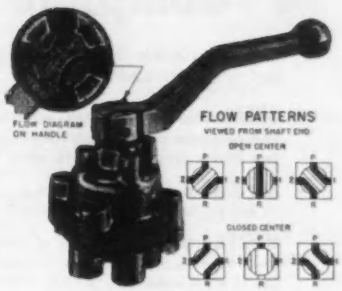
The simple rugged design of "Shear-Seal" valves pays off in an unbelievably *long service life free from maintenance* of any kind.

The *leakproof* closure of the self aligning, self cleaning valving members actually improves with the lapping action of each operation; they wear-in, where others wear-out. They are not put out of commission by dirt or erosion (wire drawing), because *flow is through, never across, sealing members.*

"Shear-Seal" valves provide excellent *throttling* action, *never freeze up*, and *without lubrication* or constant servicing of any kind.

The 4-way selector valve for 1500 p.s.i. oil service, illustrated below, has been developed with particular consideration of the *Original Equipment Manufacturer.*

Worthwhile savings, in first and after costs, are passed on through *latest manufacturing methods*, through design features with unusual *versatility* in mounting and piping arrangement, through an unmatched *trouble-free service life*.



BARKSDALE VALVES

5125 Alcoa Avenue, Los Angeles 58, Calif.

FREE USEFUL LITERATURE

Pressure Switch Selection Chart provides an easy method of finding a pressure switch for your specific application. This tabulation helps you define your requirements and saves you time in finding the correct switch for your job.

Check number M3 on the coupon below.

Piston Pressure Switch bulletin describes in detail the entire service range from 15 to 3000 P.S.I. (7000 P.S.I. proof pressure). Belongs on Production Equipment, where millions of cycles are expected, and on Original Equipment, where flexibility and price are a factor.

Check number 9612 on the coupon below.

Variable Actuation Valve Switch is outlined in this bulletin. They are bourdon tube switches with proof pressures to 12,000 P.S.I.

Check number 314 on coupon below.

The "Shear-Seal" principle is a revolutionary twentieth century advancement in valving extreme pressures as well as low pressures and vacuum. The only known method to achieve leakproof closure and maintain or improve sealing qualities with use. This patented principle is illustrated and discussed in a comprehensive bulletin.

Check number BV-2 on the coupon below.

Solenoid "Shear-Seal" Valve Catalog gives complete information on line of shut-off, diverter, 3-way and 4-way selector and 3 position selector valves for Air, Water and Oil Service to 3000 P.S.I.

Check number 1B-2 on coupon below.

Solenoid Air Valves, the famous Crescent 3-way and 4-way valves, are catalogued with complete technical description in this eight-page brochure. Where long service without valve maintenance or solenoid trouble is essential, these valves have become standard.

Check number 3C-1 on the coupon below.

New 20-page catalog includes all basic information on Barksdale Manual Shear-Seal valves, Solenoid Shear-Seal valves, Meletron Pressure Switches, and Crescent Air Valves.

Check number 3G on coupon below.

Barksdale Valves

5125 Alcoa Ave. L.A. 58, Calif.

M3 ☐ 9612 ☐ 314 ☐ BV-2 ☐

1B-2 ☐ 3C-1 ☐ 3G ☐

NAME _____ TITLE _____

COMPANY _____

ADDRESS _____

CITY _____ ZONE _____ STATE _____

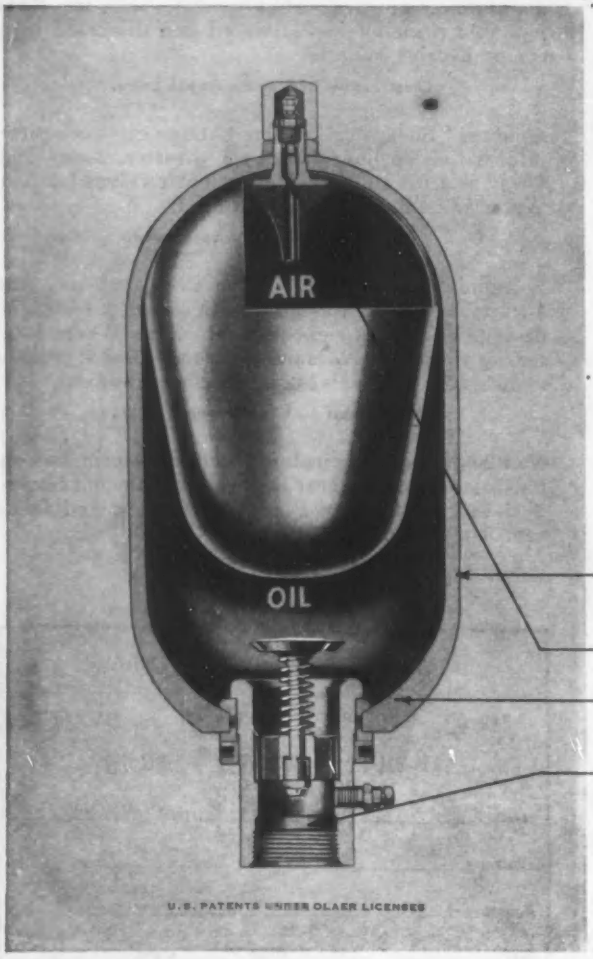
4 Important Reasons for Greer Accumulator Leadership

1 Performance

Today, more than 40,000 Greer Accumulators are in active use. They are found in every conceivable hydraulic system – in trucks, construction machinery, ships, planes, submarines and flying missiles. They power all types of presses, control steel processes, operate electric switches, and absorb pulsations in pipelines. Greer Accumulators are used effectively in almost any industry you can name.

2 Dependability

Greer Accumulators are *rugged* – each is precision-built to take many times the work load that could be reasonably expected. Proof of this fact is provided by the more than 5,000,000 cycles they have experienced. Many Greer Accumulator installations have served 8 years or more *without a breakdown.* Over 6,000 satisfied Greer Accumulator customers is an enviable and unmatched record in this field.



3 Experience

Greer application engineers are specialists in this specialized field. They *know* where accumulators belong for best performance and safety. These men can put many years of *practical* experience to work for you – experience that is hard to find perhaps impossible to match elsewhere. They are available for consultation on your request. Greer field service stands ready to serve users when and where it is needed – *anywhere in the world.*

4 Complete Safety

These exclusive built-in safety features fully protect your men and machines:

SHELL – No welds, seams or joints. Made of single-piece homogeneous chrome molybdenum steel. 18% elongation in two inches prevents crystallization. Safety margin is 5 to 1.

AIR VALVE – Absolutely leak-proof for pressures up to 12,000 psi. Integrally molded, triple sealed to prevent air loss.

MOUTH – Designed to yield at 400% of maximum working pressure. Pressure is released if system is blocked in any way. The Greer Accumulator is BURST-PROOF!

PLUG ASSEMBLY – Accumulator *cannot* be disassembled until air charge is completely released from bag. Lack of this protection has caused serious accidents.

Greer Accumulators meet all J.I.C. safety standards and conform with all safety codes of municipal, state and insurance underwriters in accordance with ASME specification on unfired pressure vessels.

GREER HYDRAULICS INC. · 454 EIGHTEENTH STREET · BROOKLYN 15, NEW YORK

Investigate the new modified polystyrene

MC-305 is the easiest to mold of Koppers "high impact" series of Modified Polystyrenes. It has been used in such large area moldings as refrigerator door liners, air conditioning housings, and television masks and tube protectors.

MC-305's high resistance to shock and impact minimizes danger of damage to molded sections during ordinary production line handling as well as during actual use. Its shock resistant qualities also make MC-305 an excellent material for toys and novelties.

Possibly you have a product that can be made better or faster or less expensively with Koppers Modified Polystyrene. To help you choose the right Koppers material for your particular job, we have prepared a new technical bulletin detailing the properties of Koppers Modified Polystyrenes. Write today for your free copy.

KOPPERS POLYSTYRENES

Type 3	General Purpose Polystyrene
Type 7	Improved Heat Distortion Temperature
Type 8	Highest Heat Distortion Temperature
MC-185	High Impact, Lowest Water Absorption Rate
MC-301	High Impact, Improved Heat Distortion Temperature
MC-305	High Impact, Easy Flow
MC-309	High Impact, Highest Heat Distortion Temperature
MC-401	Medium Impact, Improved Heat Distortion Temperature
MC-405	Medium Impact, Easy Flow
MC-409	Medium Impact, Highest Heat Distortion Temperature

Koppers Plastics Make Many Products Better and Many Better Products Possible.

KOPPERS®

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Guaranteed by Good Housekeeping

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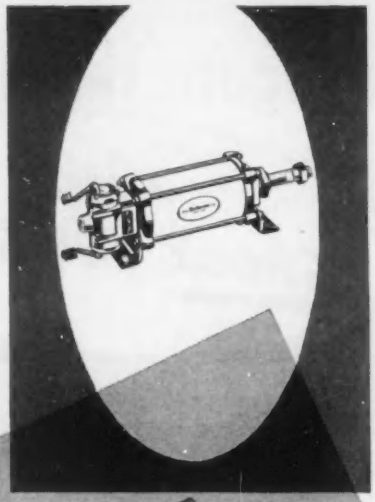
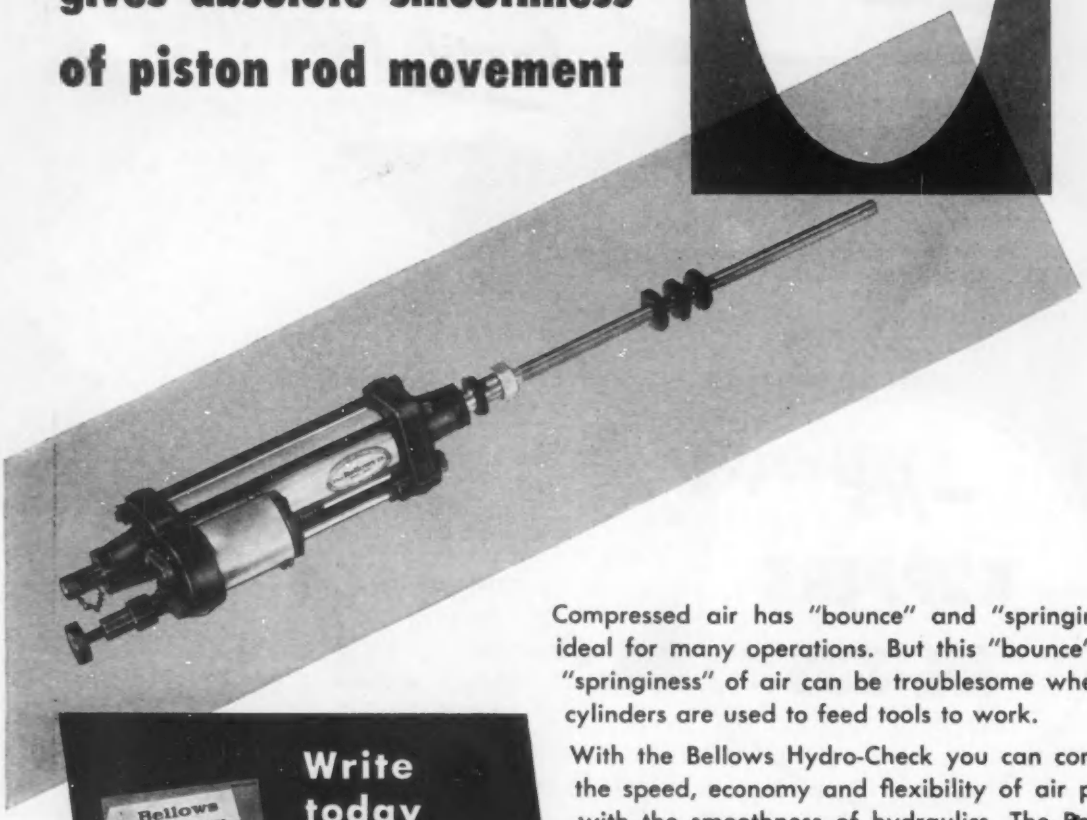
SALES OFFICES: NEW YORK · BOSTON · PHILADELPHIA · CHICAGO · DETROIT · LOS ANGELES

Hydraulic control of air cylinder operation gives absolute smoothness of piston rod movement





Compressed air has "bounce" and "springiness," ideal for many operations. But this "bounce" and "springiness" of air can be troublesome when air cylinders are used to feed tools to work.

With the Bellows Hydro-Check you can combine the speed, economy and flexibility of air power with the smoothness of hydraulics. The Bellows Hydro-Check gives an air-powered piston rod unparalleled smoothness, completely free from chatter.

Using the Bellows Hydro-Check, with any air cylinder, you can advance the tool to the work at a high rate of speed, check the advance as the tool reaches the work, feed the tool through the work at the feed rate best suited for tool and material, and with rapid return of tool to starting position.

Result: Almost twice as many minutes actual machining time each hour; longer tool life through better control of feed rate; fewer rejects.

Write today for

BULLETIN HC-600R

"Hydraulic Control of Air Power"

Dept. PE-354

The Bellows Co.

AKRON 9, OHIO

872-A

Illustrates positive adjustment of spring compression with the "Nylok" Nut.

Republic "NYLOK"* Nuts stay tight wherever you stop wrenching

The nylon plug in the side forces the nut tight against the opposite threads as the nut is turned on. You get positive locking wherever you stop wrenching even under severe vibration. Republic "Nylok" Nuts go on easily. Either end is up. No special tools, lubricants or techniques are needed. "Nylok" Nuts can be backed-off easily, too, and can be re-used.

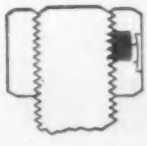
Write for samples, indicating sizes required.

12 WAYS BETTER

Assemble from either end • Can be re-used • Non-galling • Best wrenching characteristics • One-piece • Cold-forged • Won't damage threads • No special tools • Lock in any position • No special know-how • No lubricants needed • Ideal for mechanical feeding

SIZES

Finished Series tapped ¼" through 1"
Finished Thick Series tapped ¼" through ½"
Heavy Series tapped ¼" through 1"



REPUBLIC STEEL CORPORATION
Bolt and Nut Division • Cleveland 13, Ohio
GENERAL OFFICES • CLEVELAND 1, OHIO
Export Department: Chrysler Bldg., New York 17, N. Y.

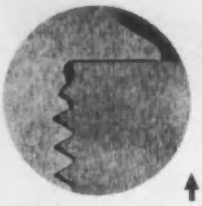
Here's how the "Nylok" principle works
A nylon plug inserted in one of the sides of the cold-forged nut forces the nut tightly against the opposite threads as the nut is turned on.

*U.S. Pat. No. 2,462,603 and No. 2,450,694 and pending applications.

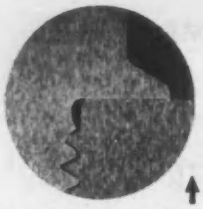
REPUBLIC STEEL
REPUBLIC BOLTS AND NUTS

Stronger!

Faster! Saves Money!



Teeth of SPIN-LOCK Screw touch bearing surface before final tightening.



Final tightening embeds teeth in surface, assuring positive locking.

That's the unique RB&W SPIN-LOCK Screw

This patented new screw rings the bell three times:

Stronger... SPIN-LOCK exerts *greater clamping force* because of its heat-treated strength. It *can't loosen* because its exclusive ratchet-like teeth lock into the surface, hold tighter than ordinary fasteners under vibration.

Faster... SPIN-LOCK needs *no washers*. It *drives easily and quickly*, even in hard-to-reach spots. *No special handling* is required—SPIN-LOCK screws can be hopper-fed.

Saves money... SPIN-LOCK's *one-piece construction* means there's just *one part to buy and stock*. Purchasing and inventory-taking move along faster, cost less. Faster assembly cuts costs. Hex, pan, truss, flat heads.

For complete data on RB&W SPIN-LOCK Screws, refer to our catalog in the PRODUCT DESIGN FILE of Sweet's Catalog.

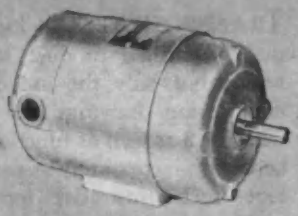
Russell, Burdsall & Ward Bolt and Nut Company—The Complete Quality Line. *Plants at:* Port Chester, N. Y., Coraopolis, Pa., Rock Falls, Ill., Los Angeles, Calif. *Additional sales offices at:* Ardmore (Phila.) Pa., Pittsburgh, Detroit, Chicago, Dallas, San Francisco. *Sales agents:* Portland, Seattle. Distributors from coast to coast.

RB&W

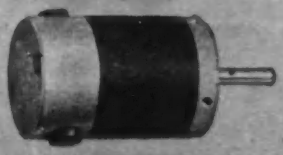
Spin-lock

U. S. Pat. No. 2,253,241

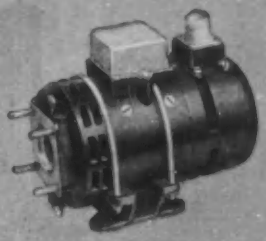
The Tighter, Stronger, Surer Fastener!



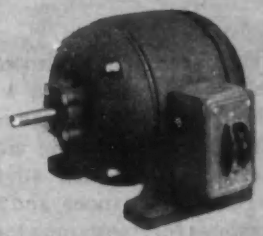
Unusually compact motor for high-speed grinders, pumps and similar products.



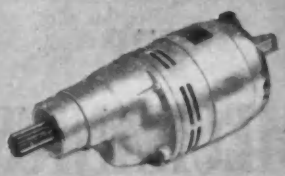
Combines sensitive performance with light weight and minimum size.



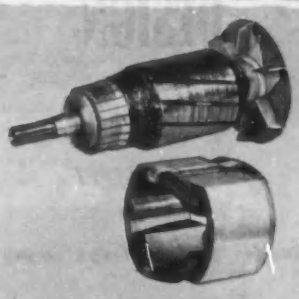
Maximum output with minimum weight . . . for many heavy-duty industrial applications.



Heavy-duty motor for sirens, saw tables and many other industrial devices.



Low weight, geared head motor for many slow-speed, heavy-duty drives.



Parts designed for applications where space economy is of major importance.

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In a recent survey, conducted by one of the leading trade journals serving the metal working field, design engineers gave the following as major objectives they were seeking through redesign of their products:

- **Reduced Costs**
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- **Improved Appearance**
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- **Greater Compactness**

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Lamb Electric SPECIAL APPLICATION FRACTIONAL HORSEPOWER **MOTORS**

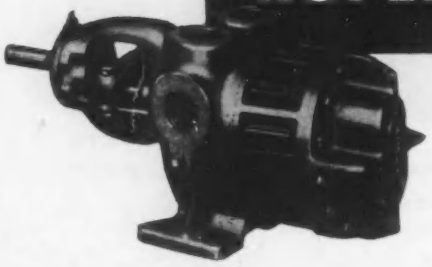
ANOTHER

HEAVY DUTY

HYDRAULIC APPLICATION

SOLVED WITH

ROPER PUMPS



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THESE techniques, although most closely associated with the industrial designer's needs, are also useful engineering tools. Their advantages and limitations, and the methods for transposing them into engineering drawings, are fully discussed and illustrated in our Special Editorial Report . . .

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DESIGN and PRODUCTION NEWS

FOR PLASTICS AND MATERIALS ENGINEERS

Published by TECHNICAL SERVICE, Chemical Manufacturing Division, The M. W. KELLOGG Company MAR. 1954

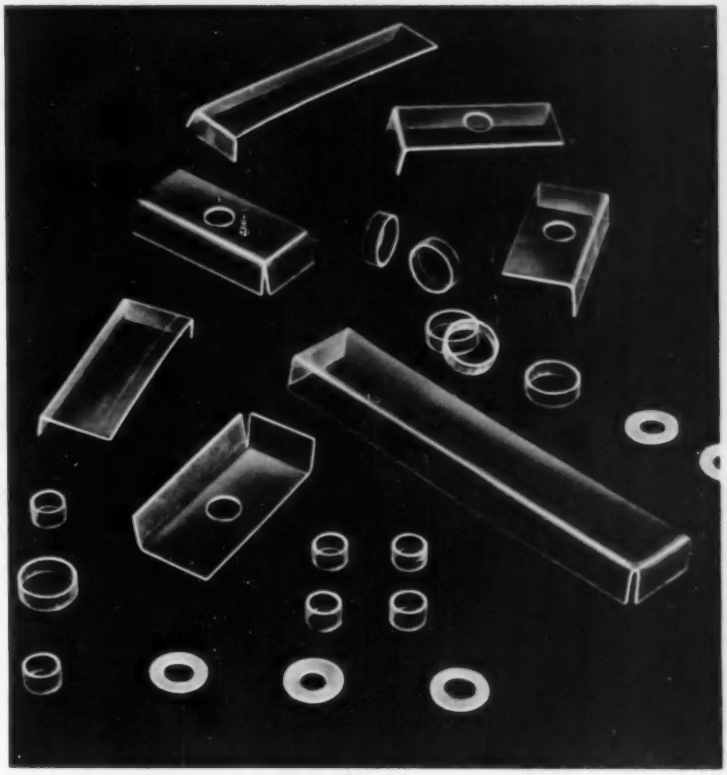
Cosmotron's 17,000 Parts of Kel-F® Keep 11 Million Joules in Check... Under 5 x 10^6 mm. Vacuum!

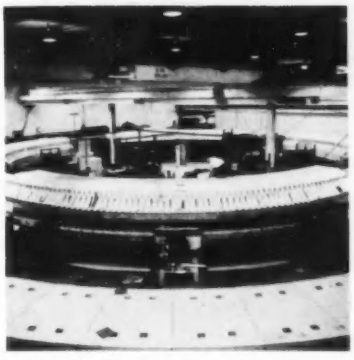
Consistently high dielectric and mechanical strength and an extremely low gassing rate are three of the unique combinations of properties of "Kel-F" polymer which are utilized in Brookhaven National Laboratory's famed Cosmotron.

Each of the Cosmotron's 2432 magnet grid bars is effectively insulated with "boots" and bolt covers whose dielectric strength remains consistently high in presence of large magnetic and electrical fields. "Kel-F"—non-porous and non-volatile—assists in maintaining the vacuum chamber at the required low pressure.

The insulating "boots" were fabricated from ½" polymer sheet stock precision-molded by Reiss Manufacturing Corporation, New York, N. Y., from unplasticized "Kel-F" polymer Grade 300. Plastone Products Company, Inc., Lindenhurst, N. Y., blanked, punched and formed the sheet to dimension. The Brookhaven National Laboratory molded the insulating washers and bushings.

For further information ask for Application Report E-120





Brookhaven Cosmotron's 2432 magnet grid bars, operating in high vacuum, are "gapped" and insulated with "Kel-F" plastic.

Have You Checked these Recent Significant Developments in Kel-F?

√ 5½ feet (dia.) inflatable "O" rings now in production for sealing chemical processing equipment.

√ *Pressure-sensitive tapes now enable manufacturers to apply dielectric or corrosion-proof coatings in their own plants.*

√ Copper plating of molded sheet opens up new applications in electronic devices.

√ *Over 300 color-coding combinations for wire now possible with printing inks of Kel-F.*

√ Coated aluminum sheet being drawn or formed into varied receptacles . . . providing non-peelable, pinhole-free protection against all corrosive chemicals.

√ *Pinhole-free film being produced from polymer dispersions for atomic energy studies.*

(SEE REVERSE SIDE)

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CONTINUED FROM PRECEDING PAGE

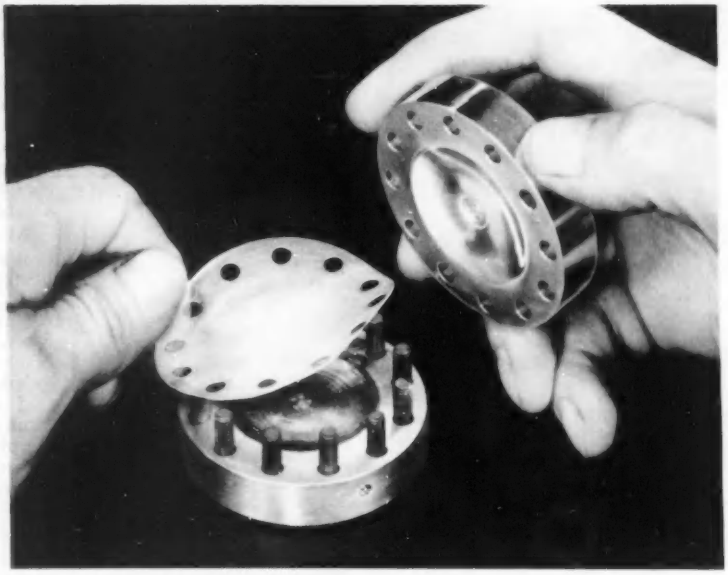
Paper-thin Diaphragms of Kel-F® Hold Back Hydrogen Peroxide up to 3000 psi . . . Yet Flex to Register Minute Variations!

Pressure of corrosive hydrogen peroxide at 130°F in a feed system is measured accurately by a standard gage, because of this tough but sensitive diaphragm of "Kel-F" polymer. It is employed in a special pressure transmitter.

Excellent flexural and tensile modulus over a wide temperature range lets the diaphragm flex at high pressures without fatigue failure. Unusual plastic "memory" preserves diaphragm form, protects measurement accuracy. The resilient membrane acts as own gasket.

The novel diaphragm is made from "Kel-F" polymer for use in the "Type 40 Isolator" manufactured for the aircraft industry by Trans-Sonics, Inc., Bedford, Mass.

For further information ask for Application Report No. C-113



Molders & Fabricators of the Month

Leading molders, extruders and fabricators specialize in the production of materials and parts made of "Kel-F" . . . each month this column will spotlight several of these companies with their principal services and products.

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Chicago, Ill.
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Rod Sheet & Tube

Cortland Industries, Inc.
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Sealing of Film

Electronic Wave Products, Inc.
New York, New York
Sealing of Film
Forming
Gaskets Container Liners

Perma-Line Rubber Products, Corp.
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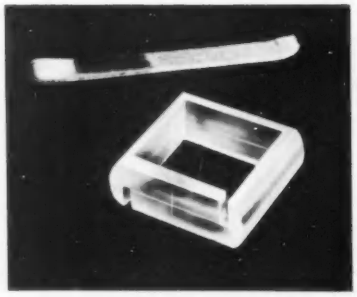
RF crystal "chases" or frames of "Kel-F" extend the effective life and improve operating characteristics of portable, fixed-frequency military radios. Excellent dielectric strength insulates against leakage of RF pulses, unbreakable frames prevent damage and permit re-use.

The ¾" x ¾" "chases" are injection molded from unplasticized "Kel-F" by Electronic Mechanics, Inc., Clifton, N.J.

For further information ask for Application Report No. E-119



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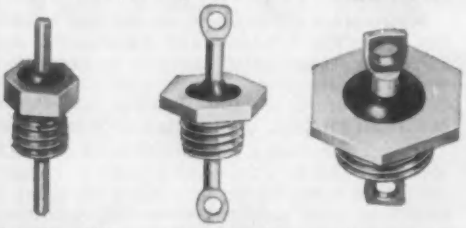
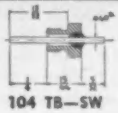
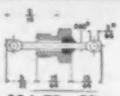


104 TB—SW 105 TB—FP 109 TB—FP

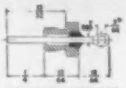
104 TB—Series	1000V (RMS)	8-32-NC-2	3/16" Hex



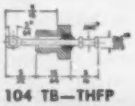
104 TB—SW



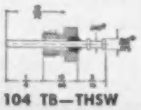
104 TB—FP



104 TB—FPSW

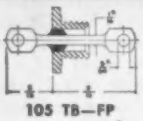


104 TB—THFP

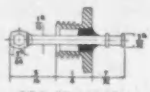


104 TB—THSW

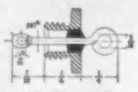
105 TB—Series	1500V (RMS)	1/4—28NF—2	3/8" Hex



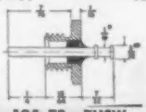
105 TB—FP



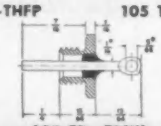
105 TB—THFP



105 TB—LFP

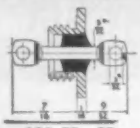


105 TB—THSW

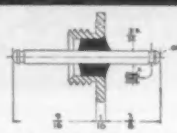


105 TB—FPSW

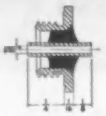
109 TB—Series	2500V (RMS)	3/8—24NF—2	1/2" Hex



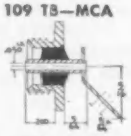
109 TB—FP



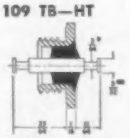
109 TB—MCA



109 TB—HT



109 TB—HTL



109 TB—TH

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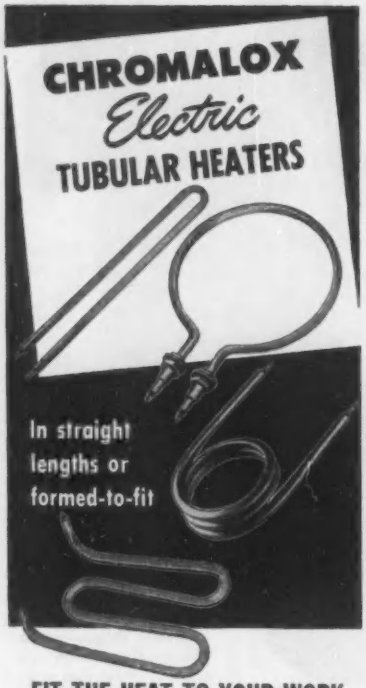

FIT THE HEAT TO YOUR WORK

Chromalox Electric Tubular Heaters are available in straight lengths or they may be curved and formed to fit your exact specifications. They provide accurately controlled, economical and dependable convection, conduction or radiant heat. Use them for dies, molds, platens; as immersion heaters in liquids, soft metal and molten salts; or in ovens, air ducts and other air heating applications. Consult Chromalox now for all your production heating needs.

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Write for Catalog 50. It lists Chromalox Tubular Heater sizes, types and ratings; sheath materials, fittings and special shapes.
CHROMALOX

IB-30A

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- New Garden City plant now operating at *top speed and quality*
- Unsurpassed facilities for quantity fabrication of *specials*
- A staff of *seasoned* engineers always available for consultation
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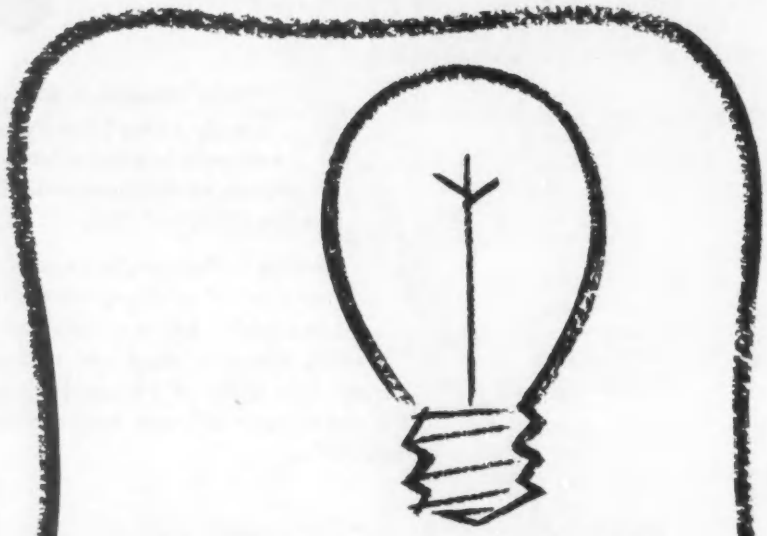
SCREW PRODUCTS COMPANY, INC.

GARDEN CITY NEW YORK



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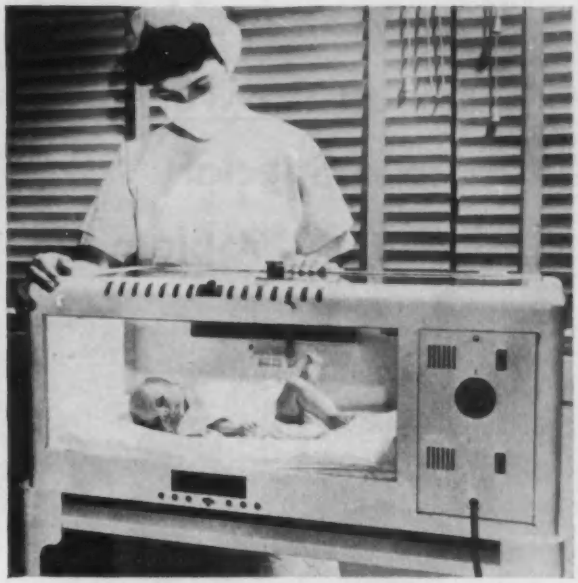
1. MEN AND WOMEN BOTH like nylon fabrics. Important key to producing successful nylon fabrics is the heat-setting process. Temperature-control must be accurate, and reliable yet readily adjustable. "National" Nylon Heat Setting Machines used by the leading textile mills employ THERMOSWITCH® units in the heated rollers . . . get highest efficiency . . . greatest safety . . . most economical fuel consumption.



2. BABY INCUBATOR MUST BE SAFE. Engineers who design Armstrong Baby Incubators say "Safety is a *must* where babies are concerned. That is why all our baby incubators are tested and approved by Underwriters Laboratories. That is why we use only Fenwal THERMOSWITCH units to control all-important temperature and humidity. Inspection reports on more than 22,000 THERMOSWITCH units show a remarkable picture of consistent reliability."

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Zenith's skill and experience have always been concentrated to one particular end—to provide the finest in specialized carburetion. Through the years Zenith has dealt with every type of engine—ranging from single cylinder lightweights to the most rugged and powerful of gasoline engines—applying 25 years of experience to the mastery of almost every conceivable carburetor problem. In engineering the individual carburetor to the specific requirements of the job, questions of placement, efficiency of performance, and economy of operation are considered from blueprint to production stage. If you are looking for the answer to a particular carburetion problem, you are looking for Zenith. Inquiries will receive prompt attention.

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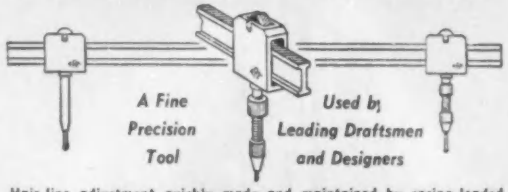

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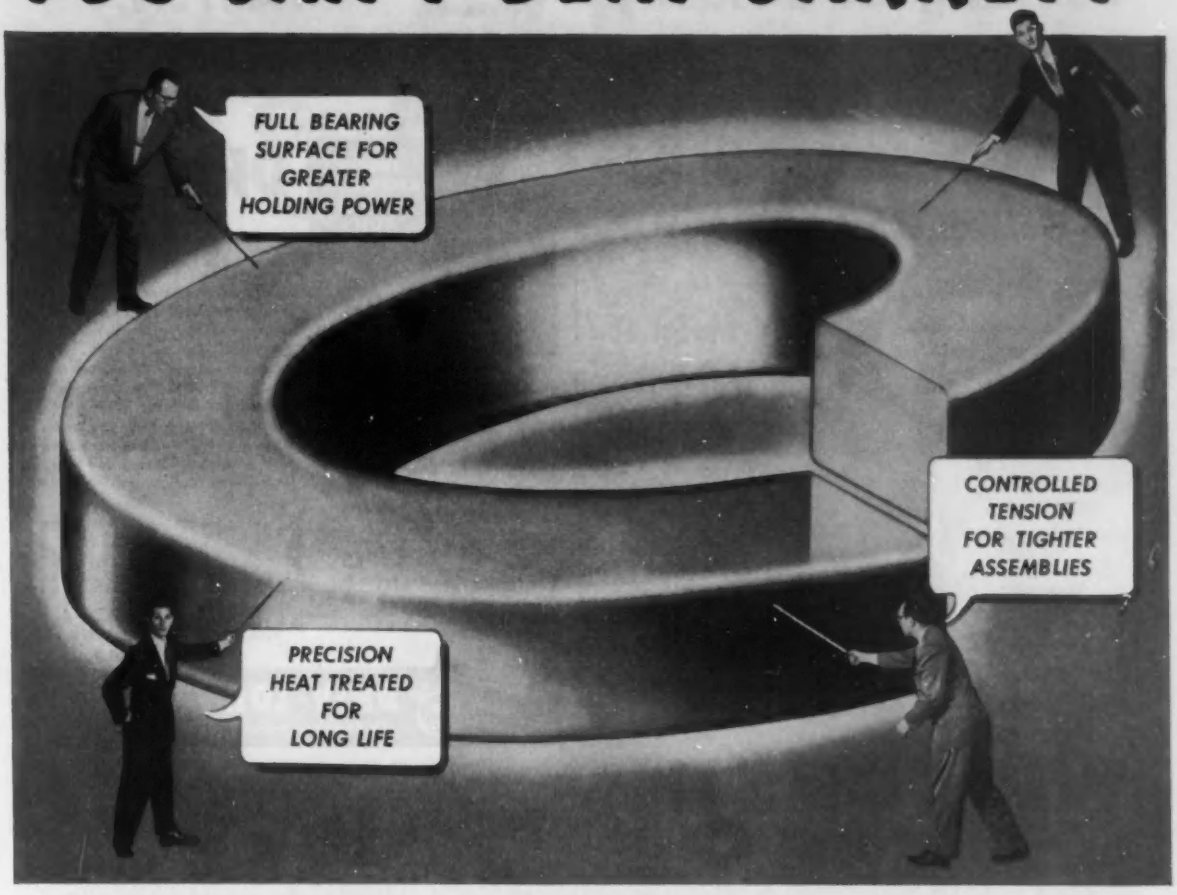
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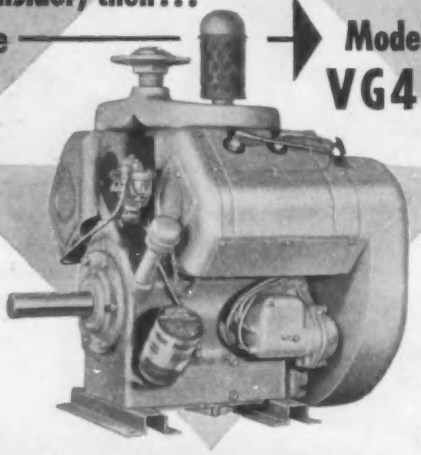
Consider, then... the → Model VG4D



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This is, without question, the most outstanding Air-Cooled Engine within its power range that has ever been built for Original Equipment Power Service. Operating in a peak-efficiency bracket from 1400 to 2400 rpm., it will handle intermittent heavy-duty loads, variable heavy-duty or continuous, constant-load jobs with smooth-running consistency and dependability.

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Model VG4D features include:

Stellite exhaust valves and valve seat inserts, plus positive type Valve Rotators, providing slow rotation of valves as they are lifted, minimizing lead and carbon deposits, adding to operating efficiency and reducing servicing costs and layups.

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Tapered Roller Main Bearings take up end- and radial-thrusts, permitting flexing of crankshaft without danger of "bell-mouthed" wear or whip, adding to smooth-running and long engine life.

Our Engineering Department will be glad to cooperate with you in adapting Wisconsin Air-Cooled Engines to your equipment requirements. Tell us about your problem. Detailed data on request.

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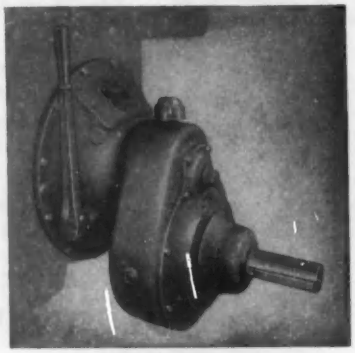
SPECIAL RATIO GEAR REDUCTION POWER TAKE-OFFS IN SMALL QUANTITIES



FUNK production facilities enable you to buy only the quantities you need of Gear Reduction Power Take-Offs in special ratios and special adaptions of standard units. Prompt delivery of special units, immediate delivery of standard models.

EXCLUSIVE STRADDLE MOUNTED PINION

This exclusive Funk development assures complete gear tooth contact at all times by providing a pinion with a taper roller bearing support at each end driven by an input shaft with a lubricated floating spline, eliminating misalignment from improper installation or load deflection.

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POWER TAKE-OFFS AND GEAR REDUCTION POWER TAKE-OFFS

WRITE FOR STOCK LIST AND STANDARD GEAR RATIOS

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Announcing the

1954 redesign contest for Gray Iron castings

1st prize $500.00
2nd prize $250.00
3rd prize $100.00

Here's your opportunity to cash in *twice* on the products or parts you have redesigned for production in Gray Iron.

First: because the unique characteristics and castability of Gray Iron helped you replace a competitive material . . . more economically and more efficiently.

Second: by entering your redesign project in the Fifth Annual Gray Iron Founders' Society's *Redesign Contest* and win one of the substantial cash awards.

Here's all you have to do . . .

1. Select the best example of products or parts that you have redesigned for production in Gray Iron.

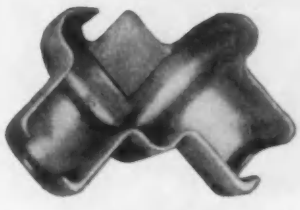
2. Give the facts for this switch to Gray Iron . . . how much you saved in labor and material costs . . . how much efficiency you gained and any other factors that led you to this decision.

3. Submit an 8″ x 10″ glossy photo of the Gray Iron casting with your entry. And, if possible, submit a similar photo of the original product or component.

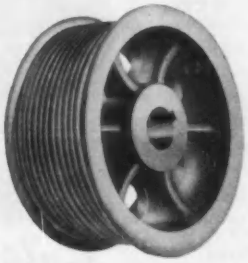
4. Get your entry in by JUNE 1, 1954 . . . closing date for contest. Address: *Redesign Contest*, Gray Iron Founders' Society, Inc., National City E. 6th Bldg., Cleveland 14, Ohio.

5. Contest is open to all persons engaged in the metalworking trades . . . entries may be entered jointly by two or more individuals.

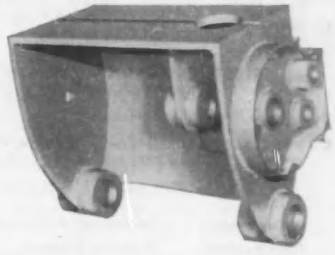
Examples of previous award winners . . . featured in the Society's recent National Trade Advertising



Production costs were cut 90% by redesigning this gear cover in Gray Iron to replace the original fabricated cover.



This cable drum was redesigned for production in Gray Iron with a cost saving of 41% per unit.



By redesigning this gearbox in Gray Iron, 45% was saved on original cost of fabricated gearbox . . . 41% on machine and labor costs.

GRAY IRON FOUNDERS' SOCIETY, INC.
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For Temperatures Between 30°F. and 700°F.

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ELECTRIC THERMOSTAT

Here is a most versatile, and yet dependable thermostat. The Wilcolator Series R has a snap action double break mechanism that provides many types of control, such as single pole—single throw, double pole—single throw, and single pole—double throw. Sensitivity is ±2% of temperature range.

ELECTRICAL RATING: 240 volts 26 amp.
125 volts 35 amp.

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Vulcanizers	Room Temperatures	Fryers
Bake Ovens	Wrapping Machines	Etc.

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THE Wilcolator COMPANY

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WIRE FORMS
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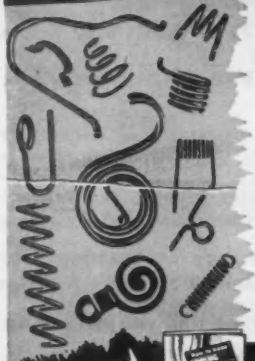

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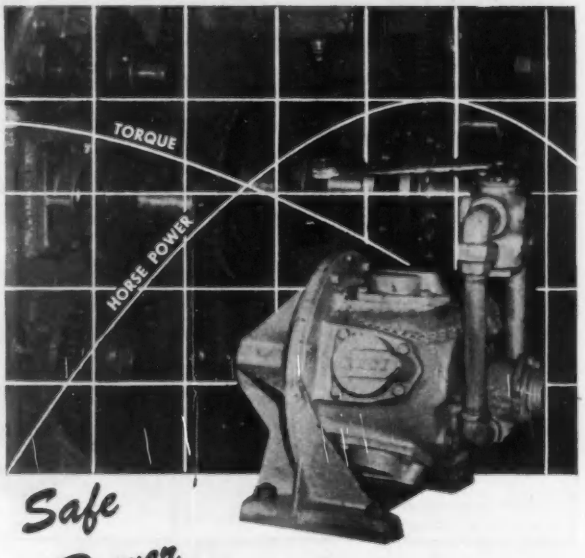

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Eimco dependable air motors provide safe power for operation in plants working with the most combustible of materials.

They are not damaged by overloads or stalling, nor is there any danger of ignition. Built in three sizes with a range from 7½-20 HP.

Available with geared reducers in a speed range from 45 to 104 RPM.

B-25

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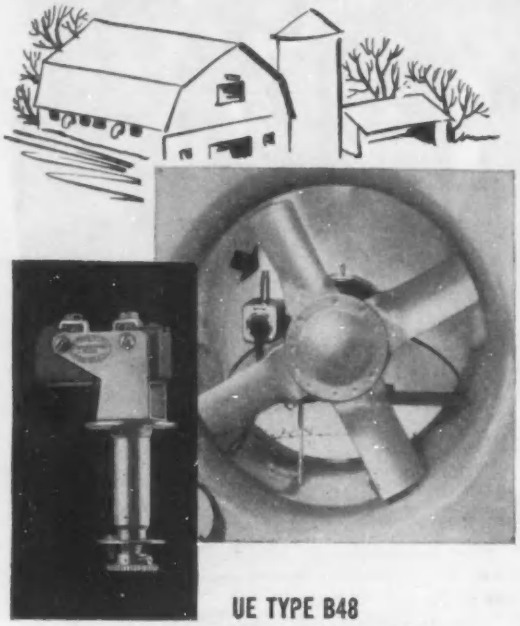
UE TEMPERATURE CONTROLS HELP FAN-PAC SYSTEMS IMPROVE BARN VENTILATION



UE TYPE B48
2-Speed Thermostat

Good ventilation at ideal temperatures of 50°F in dairy barns and 40°F in poultry houses means increased milk and egg production. These temperatures are accurately maintained by the United Electric Type B48 thermostat used in Fan-Pac ventilating systems made by American Machine and Metals Co., De Bothezat Fans Division. The Type B48 slows down – or speeds up – the two-stage motor-controlled vent fan according to the temperature change required. As Fan-Pac manufacturers state, the Type B48 is "easy to set, accurate, dust-proof, moisture-proof and fool-proof".

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REVOLUTION COUNTER→ Accurate at speeds to 4000 R.P.M.

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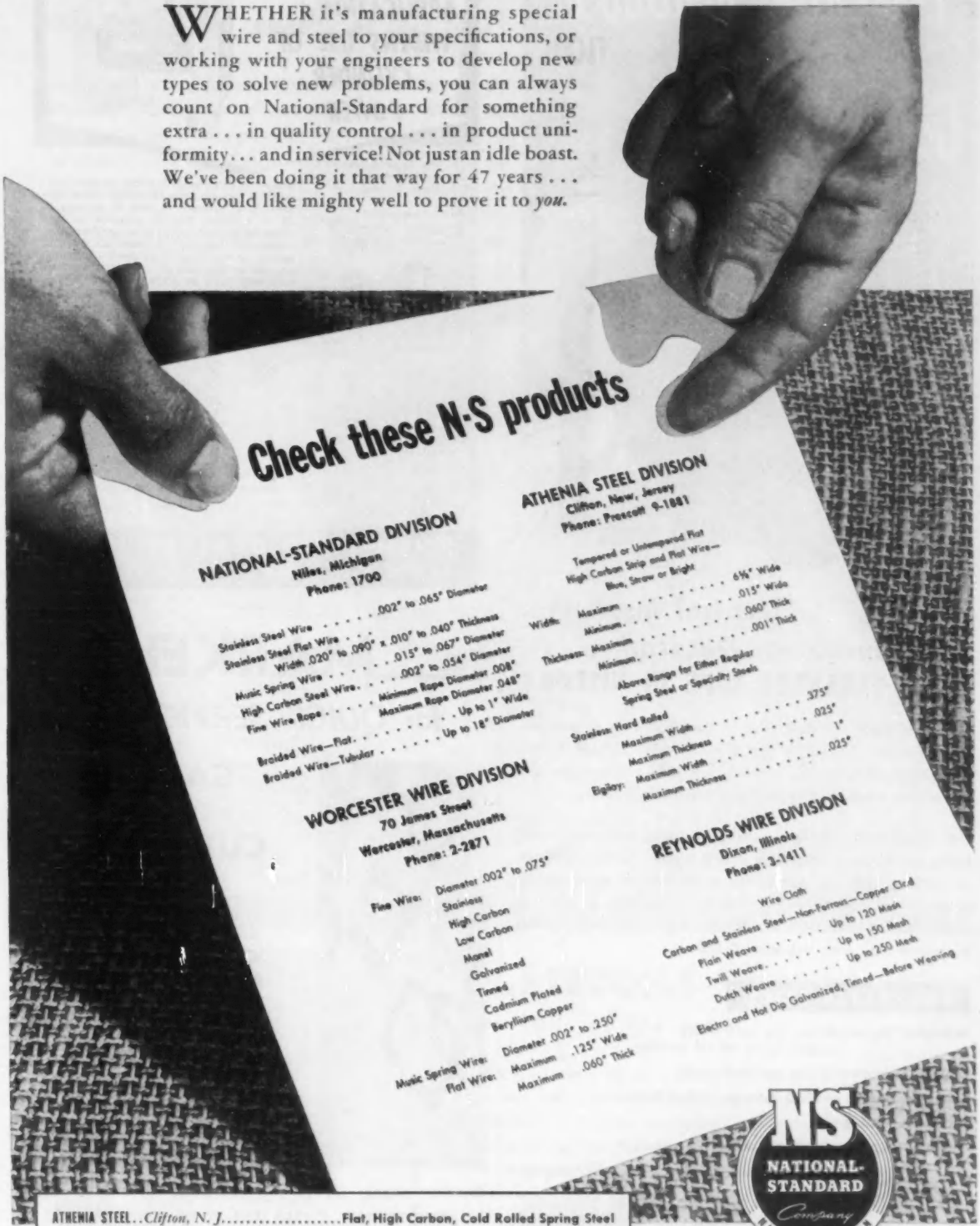
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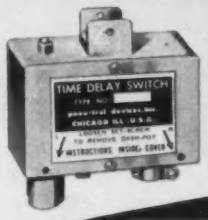
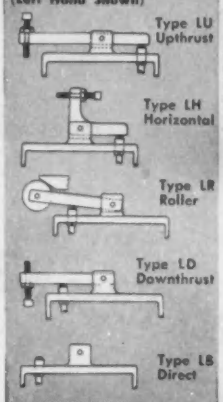
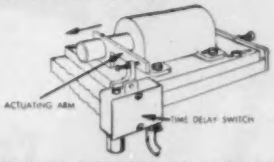
NEW CYLINDER TIME DELAY CONTROL SWITCH
INCREASES APPLICATION . . . WIDENS USE OF CYLINDER POWER



For Any Type Actuation
Left or Right Hand
(Left Hand Shown)



Pneu-Trol Time Delay Switches provide independent hydraulically controlled adjustable time dwell between ¼ and 60 seconds in 20 to 1 ratios. Readily mounted on machine for cylinder dwell at a positive stop. Compactly designed—a simplified low cost answer to electrical time dwell control of any air or hydraulically operated machine movement such as press work, burnishing, coating, quenching, metal-cutting, etc. Ideal for automatic feeders.
Dimensions: 4⅛" wide; 2⅜" high; 1-7/16" deep. Overall height 4⅛".



SWITCH MOUNTED TO PROVIDE DWELL AT END OF POWER STROKE

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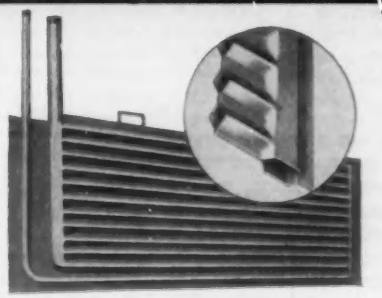
PLATECOILS *cured coil-itis* *

and tripled the capacity of this tank

In the tank pictured below at Continental Motors Corp., three crankcase sections can be cleaned at one time when Platecoils are used as the heating medium, while only one crankcase can be cleaned with pipe coils in the tank. Continental has also found that the high efficiency of the Platecoils provides fast heating for quick starts. Their flat surface coats less frequently and takes only about half the time to clean when it does.



Bulletin P77 shows how Platecoils are replacing pipe coils at a savings throughout industry. Send today for your copy.

PLATECOILS *replace pipe coils for 50% of the cost*

* Coil-itis is the constant doctoring of wet processing tanks for pipe coil troubles. It can be cured easily by replacing pipe coils with Platecoils. Immediately, you will notice the difference as Platecoils put new life and profits into your heat transfer processes. They heat or cool 50% faster and take 50% less space in the tank. They save as much as 50% in initial cost and 50% in maintenance costs in addition to overcoming the limitations and operating difficulties of old-fashioned and outmoded pipe coils.

Platecoil Division, TRANTER MANUFACTURING, inc., Lansing 4, Michigan

For fast shipment see your local distributor

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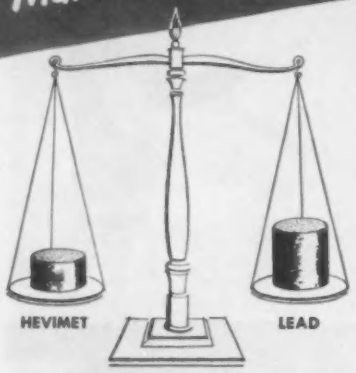

Hevimet is almost 50% heavier than lead; its volume is ½ that of equal weight of lead.

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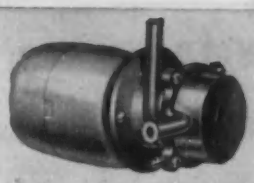
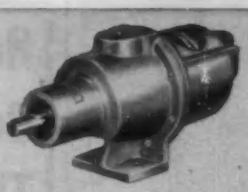
Coto PRECISION WOUND **Coils**



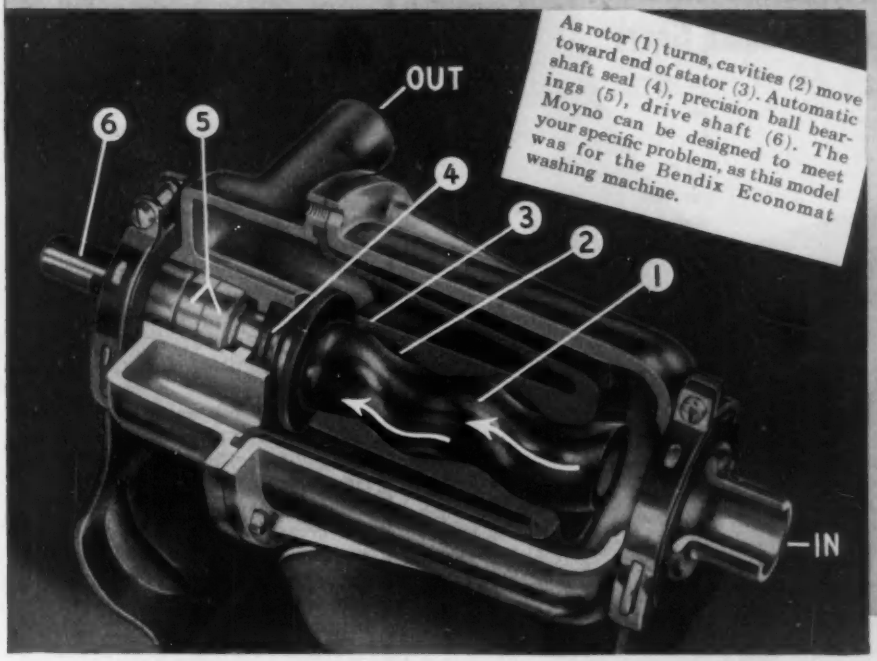
Moyno designed for pumping ethylene glycol, condensate from automatic driers, hot and cold water in dishwashers.



General purpose Moyno for pumping oils, water, alcohols and caustics.

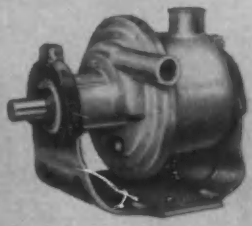
Bronze and stainless steel Moyno as used in a drink dispenser. Pumps water at more than 100 p.s.i.g.

Here's a compact version of a low head, small displacement Moyno for accurate pumping of small amounts.



As rotor (1) turns, cavities (2) move toward end of stator (3). Automatic shaft seal (4), precision ball bearings (5), drive shaft (6). The Moyno can be designed to meet your specific problem, as this model was for the Bendix Economat washing machine.

Versions of this compact Moyno are applicable as coolant pumps, shallow well pumps and booster pumps.



Economical Moyno for the appliance field, designed for use under flooded head.

BEFORE YOU "FREEZE" YOUR PRODUCT DESIGNS...

Read these FACTS *about* MOYNO® PUMPS!

One of these characteristics may improve YOUR product!

Versatile—Pumps liquids, pastes, abrasive-laden slurries. Adaptable to heavy industrial machinery or small drink dispensers, oil burners, dishwashers, sprayers, coolant pumps, etc.

Positive Displacement—Moynos are available to pull up to 29" of vacuum while discharging under pressure. Big Moynos can deliver up to 250 gpm. Pressures to 600 psi obtainable. Provide controllable, non-pulsating flow for metering purposes, in either direction!

Gentle—No churning, foaming; won't break up semi-solids. One Moyno is pumping potato salad!

Trouble-Free—Self-priming; won't cavitate or vapor-lock. Just one moving part—no valves to stick, no pistons to gum up. Low starting and running torque.

What you see here are seven variations of a *completely different concept of pump design* . . . the R&M "Moyno" Pump. It operates on a unique progressing-cavity principle, as shown by the large cutaway.

But even more important than how it works is how it *performs*. A good example is the Bendix Economat Washer, on which Moyno Pumps last *seven and a half times longer* than any pump tried before! On other types of applications—pumping everything from water, air, and abrasive-laden liquids to heavy, non-pourable pastes—users find that the simple Moyno Pump design saves maintenance dollars!

If you use pumps—and particularly if your pumping application is a little different—*there's a strong possibility that the Moyno can add new features to your product.*

New Bulletin No. 50-PD has more facts

Contains performance curves and details on pumping characteristics. Write for your free copy. If you can describe your application, we will be able to reply in even more detail. PD-113

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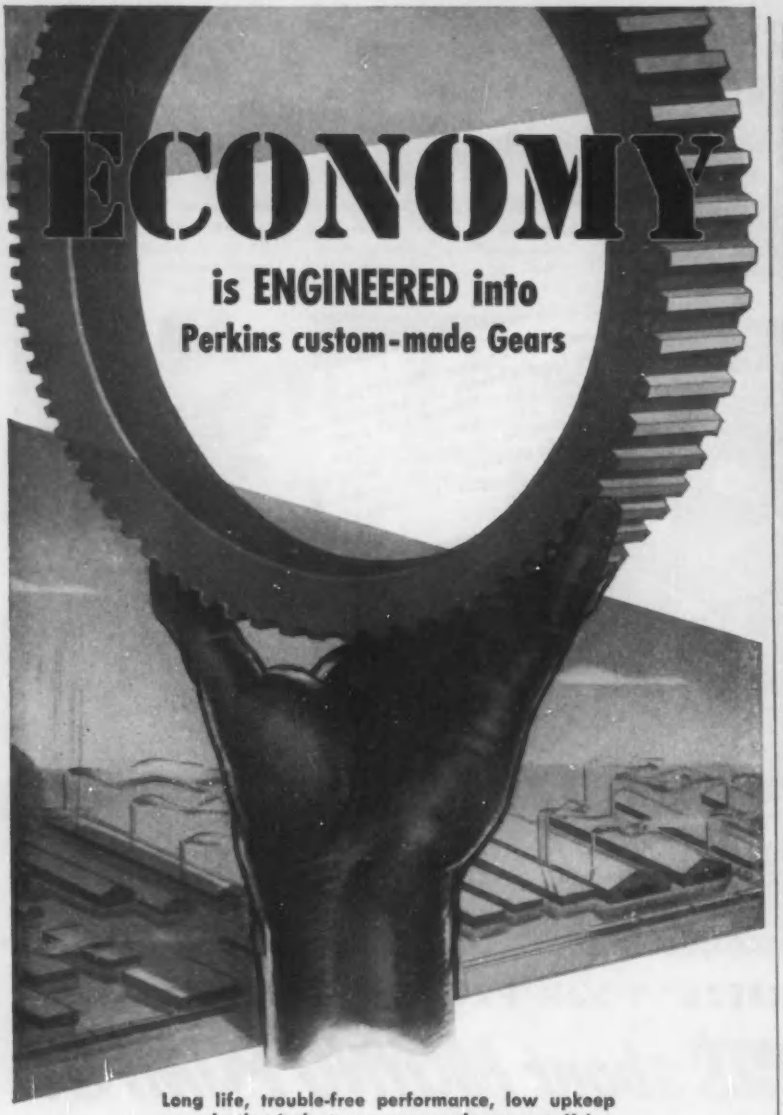

Long life, trouble-free performance, low upkeep record—that is the true measure of gear cost. Using those factors as a means of comparison, PERKINS GEARS cannot be surpassed. As a result, you will find PERKINS PRECISION GEARS in the power transmission systems of the finest products made by industry throughout the United States.

As one of the country's leading gear engineering organizations—solidly backed by a tradition of New England craftsmanship, we are able to produce—to your specifications—any size gear, in any material and in any quantity. Ask us to quote on your requirements.

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NOTE 1: A new product is the **Perkins Precision Spring Coiler.** This coiler (patent applied for) turns out precision springs—any type, shape, size, from wire sizes .005 to .125.

2: Another new product—the **Perkins "Bendit 15"**—a patented metal forming machine bends and shapes sheets, rods, strips tubing into innumerable complex as well as simple forms that would be difficult or impossible to make by other means. Eliminates need for expensive tools or specialized skills. Ht. 47", net wt. 200 lbs. Write today for descriptive catalogs, prices etc.

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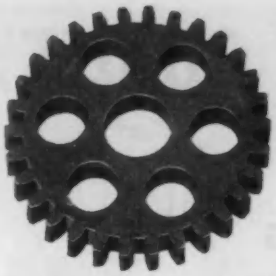
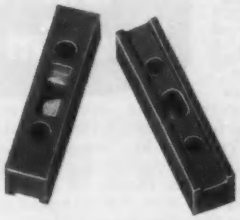


Making this intermediate wringer-drive gear of iron and copper powder saves the Whirlpool Corporation, St. Joseph, Michigan, up to $20,000 per year. The part was formerly made from a 3/8" blank which was pierced, flattened, machined for teeth; wire brushed for burr. Tolerances on the powder metal part are identical with those by machining.

The part shown is a card register block for IBM machines. Close dimensional tolerances are required as the part is used in a precision machine. The screw holes are tapped. As compared with machining the part represents a saving of approximately 82% in cost!

A valve disc sleeve used in the air release mechanism of a Neptune Red Seal petroleum meter was originally made of brass rod stock, then of die-cast zinc (which proved unsatisfactory) and now of powdered brass. Corrosion resistance is adequate; tolerances are ±.001" on two diameters. The part costs no more than the unsatisfactory die casting; approximately 1/3 that of the machined part.



Here are shown top and bottom of a powdered iron block that forms the structural base for the shearing head of a Schick Electric Razor. Dimensional stability is an important requirement. Powdered iron — replacing SAE 1020 steel bar stock—saves 7 machine operations and effects a saving of 50% in cost.

For Parts Like These... Powder Metal is a BIG Economy

Parts with involved contours that require multiple shaping operations . . . parts which cause heavy scrap losses . . . should be made of powder metal.

Brass, bronze, and iron powders, or mixtures, make powder metal parts at a single stroke to close tolerances . . . with coining to ±.001" . . . to tensiles of 70,000 psi . . . as high as 100,000 psi or more for special applications.

Stokes makes the presses that make the powder metal parts . . . offers you the experience of over 30 years in setting up for this modern, low-cost high-production method.

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Another IBM part: This oil pump rotor is used in several IBM machines. Saving in cost as compared with a machined part, says IBM, is 84%! Total tolerances of .001" and .0.2" are required. Powder metal processing eliminates all machining operations, which previously required 20 hours per 100 pieces.

All the parts which illustrate this page are made by The Presmet Corporation, Worcester, Massachusetts, a custom supplier of high-precision powder metal parts. Like most powder metal parts producers, Presmet relies heavily on Stokes Presses.

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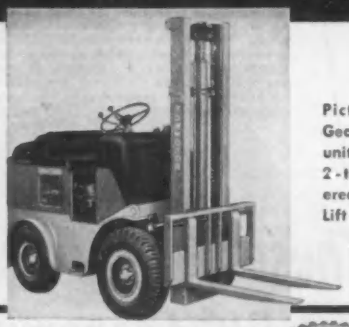
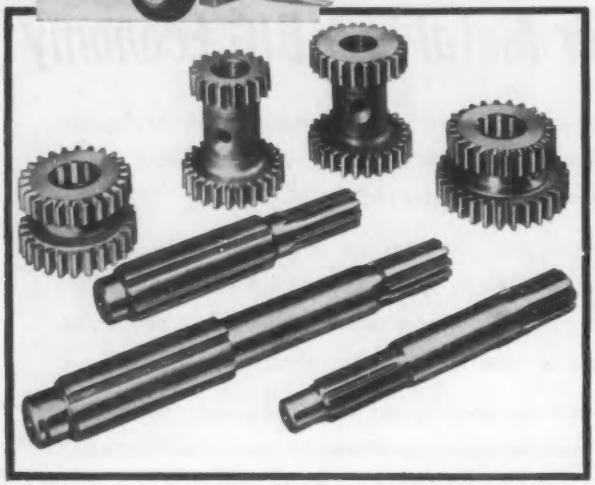


Pictured here are Ohio Gear's power transmission units used in Towmotor's, 2-ton load, Diesel powered model 480-PD Fork Lift Truck.

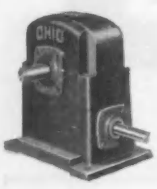


Towmotor's "one man gang" is designed to "take it" and the many factors that go into manufacturing a lift truck must be equally as rugged to withstand a lift truck's round-the-clock grind.

Towmotor units operate the world over — loading ships — lifting steel coils and bars to trucks or stacking lumber, stone and finished products. Do you know of a greater test for gears?

Towmotor depends on Ohio Gears to insure their products' operation and reputation at home and abroad.

Towmotor is another good reason why more automotive designers are specifying Ohio Gears. Perhaps Ohio Gear can do as much for your product. See their nearest distributor or write direct.



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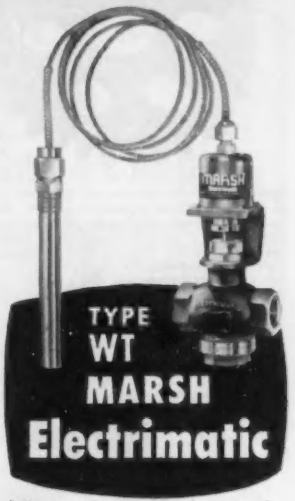

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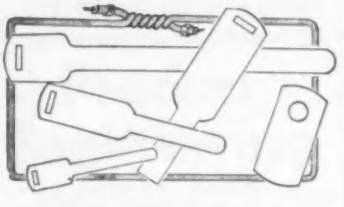

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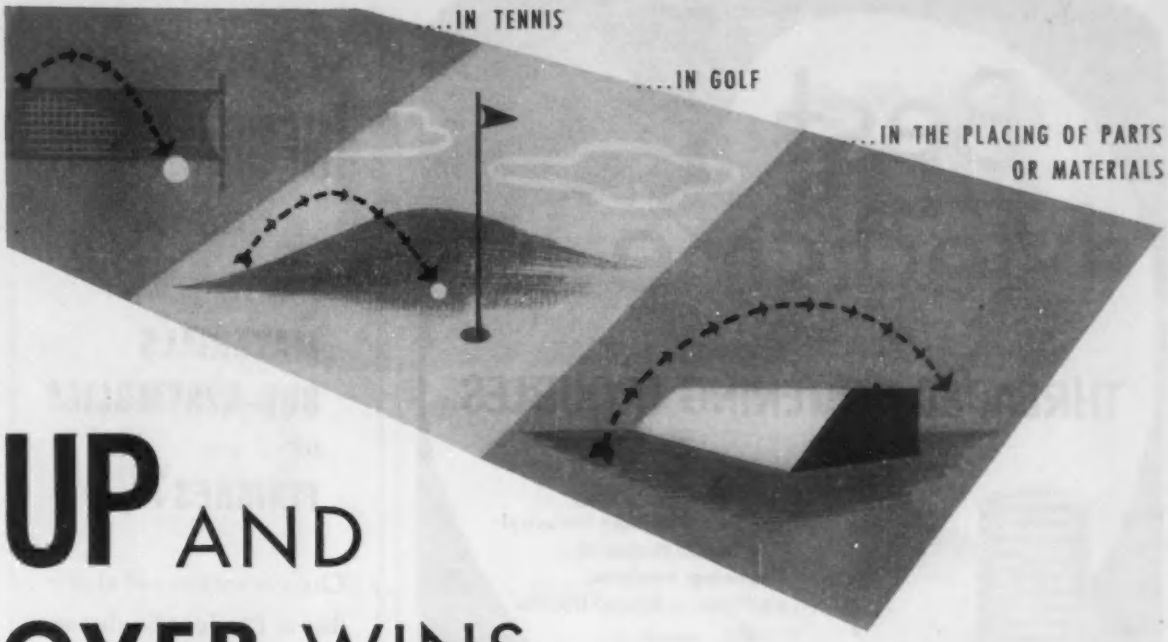

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Anyone can move parts or materials through single planes and place them in position. Two plane positioning, such as moving a part horizontally and then lowering it vertically, is somewhat more difficult. But three plane positioning, lifting a part up and over an obstruction and placing it with complete precision, needs a V & O Feed-O-Matic.

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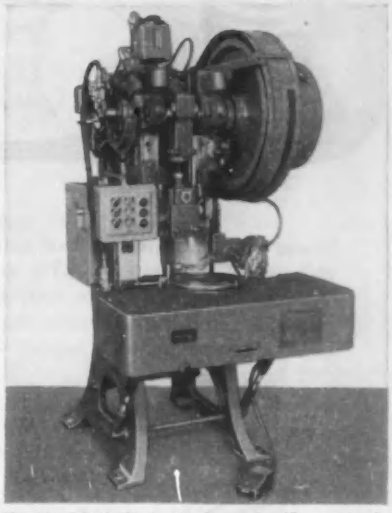
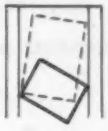
Three plane precision positioning is practical. You can design to use it. Write us and find out how and why.



The Feed-O-Matic is simple and self contained, well enclosed, but highly accessible for servicing.

WHY THE V & O LONG SLIDE PROVIDES BETTER ALIGNMENT



With the same running clearance, the longer the slide the less the possibility for angular misalignment. And we keep our running clearances very close indeed.

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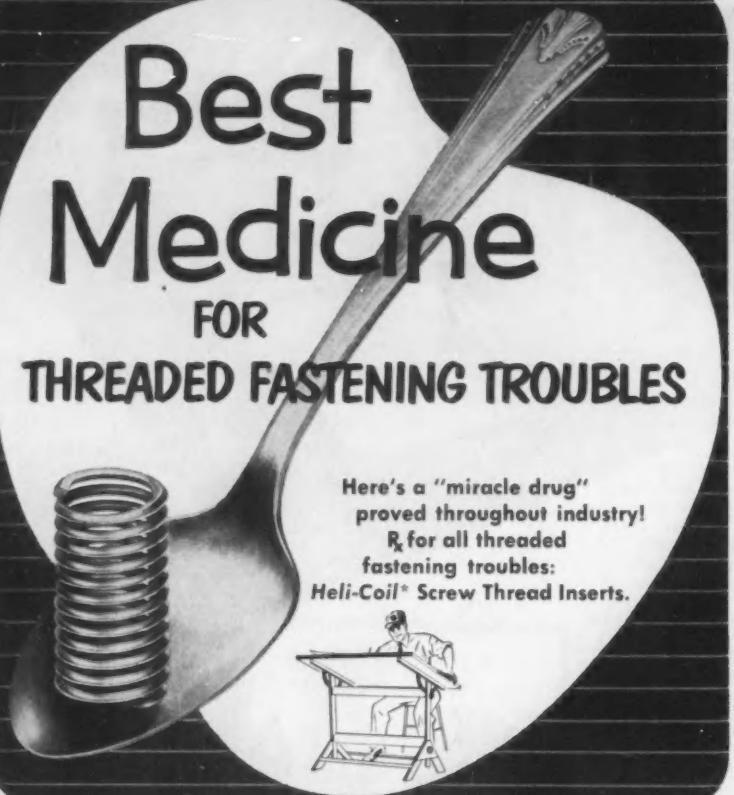

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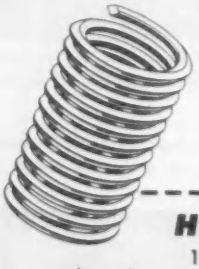

Heli-Coil **Inserts conform to official Military Standards MS-122076 (ASG) through MS-124850 (ASG) and others.**

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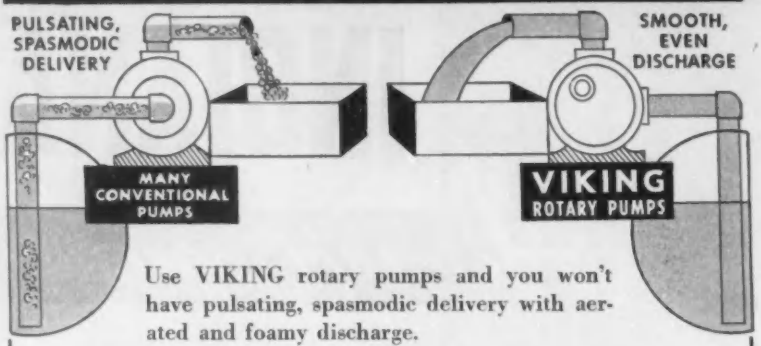

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FINE WIRE PLATING - platinum, gold and silver, plated on fine wire to extremely close tolerances.

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If your plant is not ready with a disaster plan, better act now. There's not a single American plant that's out of range of an intercontinental bomber—and fires, floods, tornadoes or explosions can kill you just as dead as an atom bomb.

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☐ **Check contents** and locations of first-aid kits. Be sure they're adequate and up to date. Here, again, your CD Director can help. He'll advise you on supplies needed for injuries due to blast, radiation, etc.

☐ **Encourage personnel** to attend Red Cross First-Aid Training Courses. They may save your life.

☐ **Encourage your staff** and your community to have their homes prepared. Run ads in your plant paper, in local newspapers, over TV and radio, on bulletin boards. Your CD Director can show you ads that you can sponsor locally. Set the standard of preparedness in your plant city. There's no better way of building prestige and good community relations—and no greater way of helping America.

Act now . . . check off these four simple points . . . lives are at stake . . . have you a right to delay?

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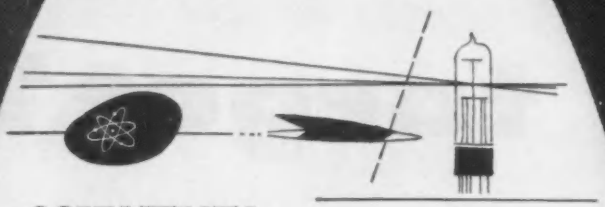

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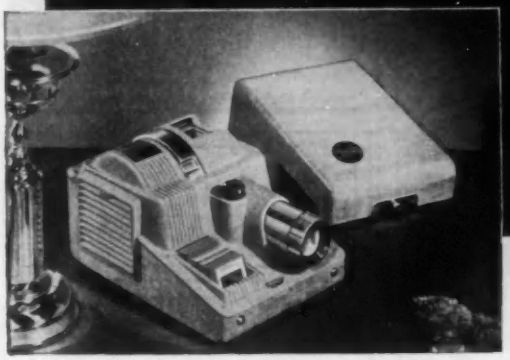

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Extreme accuracy is the priceless ingredient that makes a fine Screw Machine Part *finer!* That's why Revere Camera Company of Chicago "Turns to TOUREK" for the lens mount for their revolutionary new 444 Slide Projector. This precision part features among other operations, critical internal and external fine pitch threading.

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Helpful technical data for speedy reference purposes, is ready for you now! It contains useful information on TOUREK Ball Joints, Pipe Plugs, and Screw Machine Parts. Write for it on company stationery, please!

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THIS IS ALL YOU DO—Just insert collar of Midland Welding Nut in hole for bolt or screw, resistance weld the Nut in place, and the *nut is there for the life of the job.* Nuts can be automatically fed to the welder. No time wasted or trouble screwing-on nuts in hard-to-get-at places. Write for facts about these better connections at *less cost.*

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NEED BETTER CASTINGS?

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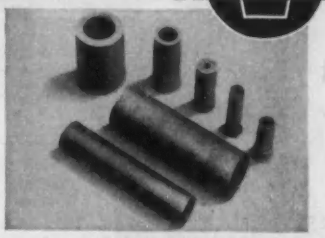

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With broad experience on tooling of small precision electro-mechanical assemblies for mass production. Must be A1 administrator. Responsibilities—tool engineering, toolroom-machine design and procurement-methods. Well established independent company, 1500 employees. Good future to man who can deliver. Submit complete resume. Replies confidential

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(Continued on the following page)

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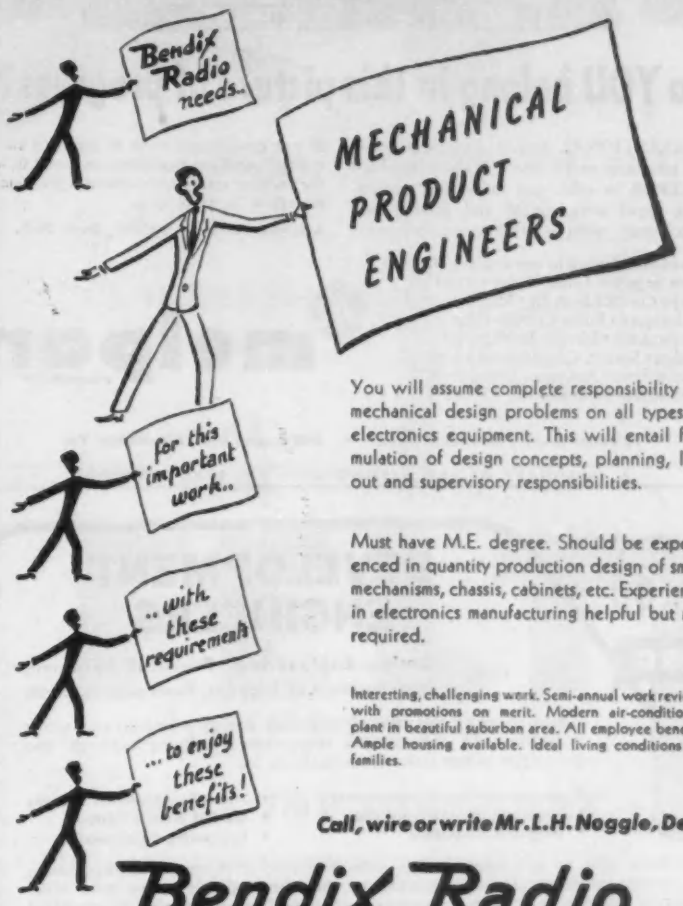

You will assume complete responsibility for mechanical design problems on all types of electronics equipment. This will entail formulation of design concepts, planning, layout and supervisory responsibilities.

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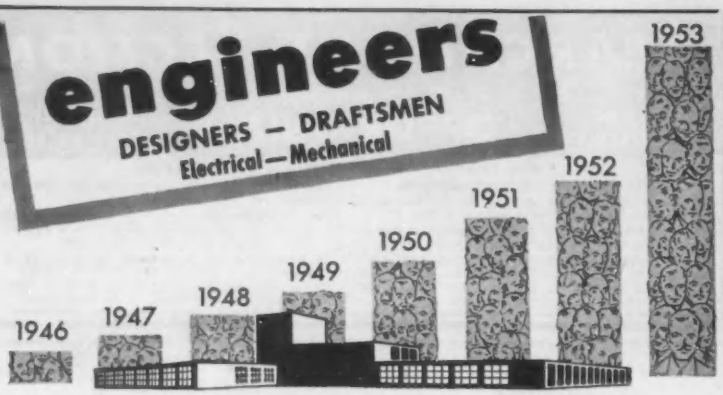

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Division of the Sperry Corporation

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DESIGN DRAFTSMAN, age 35, with 15 years experience in small/med. machine design, seeks post in New England. Would prefer work on special purpose automatic machinery such as paper converting or packaging. PW-1758, Product Engineering.

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ELECTRICAL ENGINEER, 39, (now employed). 13 years engineering experience comprising, electrical control, including industrial, electronic and naval. Design of electro-magnetic devices of industrial and naval type. Supervisory and administrative ability. PW-1866, Product Engineering.

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GENERAL ENGINEERING

Accelerometers 304, 337
Books 400, 448
Catalog Services 334
Computers 337, 373
Drafting
Instruments 428
Machines 260, 293
Supplies.....260, 293, 338, 348, 394, 400
Dynamometers 324
Furniture, Drafting Room.... 260
Furniture, Office 348
Photographic Equipment Paper 71
Profilometers 422
Recorders 43, 271, 337
Reproduction Equipment 71, 260, 293
Reproduction Supplies..... 71, 260, 293
Spectrometers 337
Testing Machines & Equipment..269, 277, 304, 337 348, 414
Tracing Cloth 394
Transducers 337
Vibrators 4, 60, 410
Vibratory Equipment 251, 304, 337, 410

DEVELOPMENTS IN METALS & ALLOYS

Aluminum Alloys..64, 78, 279, 321, 343-344
Aluminum Coated Sheet & Strip 220
Bars..24-25, 64, 107, 279, 317, 321, 343-344, 360, 368, 392
Beryllium Alloys 31
Bi-Metal 258
Brass 78, 102, 368
Bronze 102, 317, 368
Carbide Alloys 463
Clad Metals....31, 252, Insert between pp. 388 & 389, 408
Copper & Copper Alloys...78, 102, 289, 317, 368
Expanded Metals 326
Extruded Shapes.....64, 78, 279
Gold Alloys 31, 408
High Temperature Alloys.... 31, 360, 404
Laminated Metals.....31, 355, 361, 408
Magnesium Alloys 336
Metal Powder.....48-49, 68, 252
Nickel Alloys.....33, 42, 289, 360
Palladium Alloys 31
Phosphor Bronze 289, 368
Pipe 85
Plated Metals 446
Plates 336
Platinum Alloys 31, 408
Powdered Metal Parts..48-49, 68, 317, 390, 441
Rings 48-49, 68
Rods 102, 279, 321, 343-344, 360, 368
Rust Proofing 8
Sheets..64, 336, Insert between pp. 388 & 389
Silver Alloys 252, 408
Specialty Metals 438
Steel
Alloys 24-25, 40-41, 88, 220, 341, 360
Carbon 24-25, 40-41, 78, 88, 220, 349
Coated 40-41, 220
Stainless.....40-41, 86, 107, 220, 253, Insert facing p. 292, 341, 360, 423, 425
Tool 88, 341, 360
Strips .....40-41, 102, 279, 289, Insert facing p. 292, 349, 360, Insert between pp. 388 & 389
Structural Shapes 279

(Continued on Page 456)

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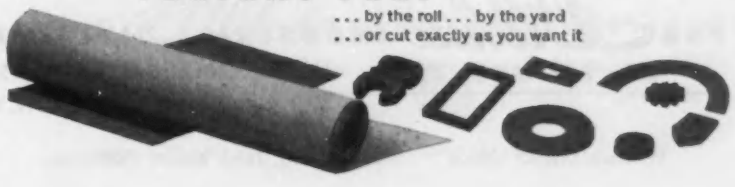


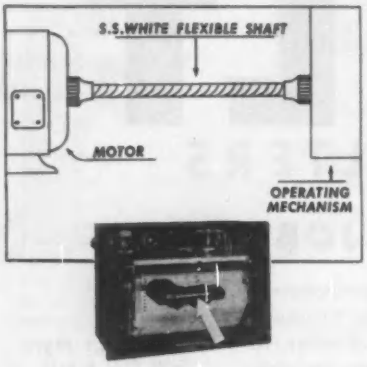
THE PROBLEM

ELIMINATING VIBRATION AND ALIGNMENT TROUBLES

In the sensitive recording pyrometer shown below an electric motor is used to drive an operating mechanism. Since any vibration caused by misalignment of the connected spindles would affect the accuracy of the instrument, the problem was to develop a coupling which would automatically compensate for misalignment. In solving the problem, the designer chose

THE LOW-COST SOLUTION

AN S.S.WHITE POWER DRIVE FLEXIBLE SHAFT



The short coupling shaft that was used provided a positive, vibrationless linkage which eliminated the need for aligning the connected spindles. This not only assured better operation, but it also simplified assembly and reduced production time and costs. It will pay you to consider S.S.White flexible shafts whenever you have to transmit rotary power between two points. They're economical and dependable and often make possible substantial savings in manufacturing and assembly costs.

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Index of PRODUCTS ADVERTISED In This Issue

•

(Continued from Page 455)

Titanium 4, 60, 69
Tubing
Precious Metal 408
Seamless....64, 78, 107, 110, 241, 253, 279, 286, 361, 425, 437
Welded.....2, 78, 85, 241, 286, 329, 360
Tungsten Carbide 463
Wear Materials 404
Wire Cloth 311, 448
Zinc 12
Zinc Coated Sheets.....40-41

NON-METALLIC MATERIALS & FINISHES

Adhesives....106, 218, Insert between pp 356 & 357 (Silicone), 417
Carbon 48-49, 68
Ceramics 4, 60, 298
Chemical Treatments..8, 265, 276
Chemicals 415
Coatings...8, 106, 265, Insert between pp. 356 & 357 (Silicone), 386 Insert between pp. 420 & 421
Cork Compositions 53, 79, 462
Electrochemical Finishes & Treatments 276, 336
Extruded Shapes 320
Fabrics 380
Felt 356, 455
Fibre.....287, 332-333, 395
Fibre Glass 50
Graphite 48-49, 68
Insulation.....43, 50, Insert between pp. 356 & 357 (Silicone), 378
Leather .....2nd Cover, 308
Paper 332-333
Plastic Film 218
Plastic Parts....258, 285, 287, 375 396, 399
Plastics..22-23, 36-37, 47, Insert between pp. 64 & 65, 218 287, 350, 375, 399, 415, Insert between pp. 420 & 421
Plastics Fabricated...287, 375, 396
Plastics Laminated.....285, 287 294-295, 332-333, 395
Porcelain 365, 378
Resins .....47, 67, 218, Insert between pp. 356 & 357 (Silicone), 415
Rods.....285, 287, 320, 332-333
Rubber....2nd Cover, 83, 266, Insert facing p. 292B, 370, 376 381, Insert between pp. 420 & 421, 436
Rubber Parts....2nd Cover, 36-37 256, 258, 308, 370, 376
Sealants 106, 467
Sealers 106, 380
Sheets
Plastic...218, 285, 332-333, 396
Rubber 376
Silicone Rubber....Insert between pp. 356 & 357, 376, 380
Silicones..287, Insert between pp. 356 & 357
Tapes.....Insert between pp. 356 & 357 (Silicone), 462
Tubing
Plastic 285, 287, 320 332-333, 396
Varnish..Insert between pp. 356 & 357 (Silicone)

FABRICATION & PRODUCTION PROCESSES

Anodes 43, 252
Assemblies 336, 347
Cabinets 336

Index of

PRODUCTS ADVERTISED

In This Issue

Carbon Parts 338
Castings.....18-19, 54-55, 247, 306, 315, 384, 421, 431
Castings, Precision Investment 282, 338, 404
Deep Drawing 336, 393
Die Castings..34, 51, 80, 273, 428
Dies 468
Engineering Services (See also Production Services) 62, 336, 375
Extrusions 279, 370
Fabricated Plastics...285, 287, 396
Fabricated Steel 347
Finishing Equipment 347
Fixture Clamps 377
Forgings...237, 247, 275, 279, 305, 309, 403, 464
Inspection Equipment 348
Laminated Plastics 285, 287
Lubricant Systems 265
Metal Forming 336, 393
Moldings
Plastics.. 285, 360, 375, 396, 399
Powdered Metal..48-49, 68, 267, 317, 390, 441
Rubber....2nd Cover, 36-37, 256, 258, 314, 370, 376
Plating, Precious & Base Metal 444
Press Brakes 468
Production Machines & Processes....51, 310, 318, 347, 441
Production Services...62, 298, 336, 362, 389, 393
Punchings, Plastic 285
Rings & Loops.....26-27
Rubber-Bonded-to-Metal 256, 376, 379
Screw Machine Parts.....279, 451
Shapes & Shells Deep Drawn 336
Spraying 393
Stampings..51, 393, 429, 432, 436
Structural Forms 279, 347
Subcontracting Services...336, 389
Tanks 347
Weldments 235, 347, 447
Wire Forming 43, 432

POWER TRANSMISSION ELEMENTS

Actuators 271, 291, 351
Axles.....354, 372, 411
Belts...36-37, 44-45, 103, 237, 308
Brakes
Electric 100-101, 459
Pneumatic 227, 397
Chains
Bead 307
Roller 35, 461
Silent 11, 35, 44-45
Clutches
Electrical 100-101, 459
Hydraulic 303
Mechanical 16, 227, 303, 360, 388, 422, 430
Pneumatic 227, 397
Couplings
Hydraulic 381, 383, 405
Mechanical.....251, 328, 342
Drives, Hydraulic 303
Drives, Timing 44-45
Drives, Variable Speed..3rd Cover 59, 89, 108-109, 122, 297 318, 342, 409
Flexible Couplings....35, 122, 251 306, 335, 379, 383
Flexible Shafts 456-457
Friction Materials 36-37, 79
Gear Motors 122, 409
Gears..6, 75, 99, 111, 122, 264, 270 312, 319, insert facing p. 324 335, 346, 364, 372, 408, 440 442, 445
Motor Reducers (See also Gear Motors) 3rd Cover, 82, 99, 111 122, 243, 263, 335, 419
Power Take-Offs.....303, 360, 430
Pulleys 318, 342

(Continued on Page 458)

THE PROBLEM

DEVELOPING A SENSITIVE 90° CONTROL

A manufacturer of analytical balances wanted to provide his equipment with a vernier slide control which could be operated outside the case in which the balance was housed. He found that he could do this by mounting a control knob on the side of the case, but by so doing the axis of the control knob would be at right angles to the vernier control shaft. The problem was how to make the necessary 90° turn with a coupling that would have minimum "backlash" and would still be easy to assemble. He found the answer in —

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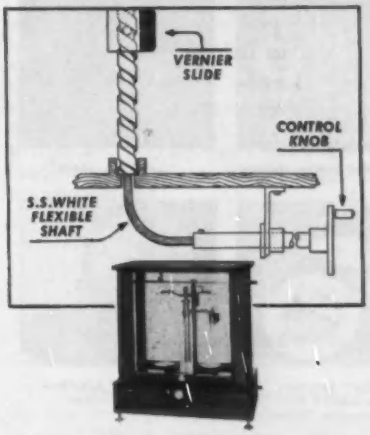
AN S.S.WHITE REMOTE CONTROL FLEXIBLE SHAFT



As shown by the drawing at the left a single, easily installed .130" diameter shaft was all that was needed. This shaft has negligible deflection characteristics and met all requirements of the application including sensitivity, simplicity and low cost. Why not discuss your remote control problems with S.S.White engineers. They can suggest many ways in which flexible shafts can be used to reduce costs and improve product design.

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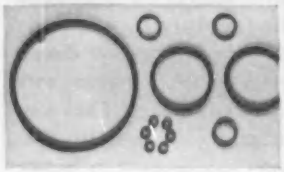

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MECHANICAL SEALS
RUBBER EXPANSION JOINTS

Index of PRODUCTS ADVERTISED

In This Issue

(Continued from Page 457)

Rachets 440
Sheaves 388
Speed Reducers...82, 99, 111, 122, 297, 312, 335, 388
Splines 122
Sprockets.....35, 122, 346, 440, 442, 461
Torque Converters 430
Transmissions.....99, 108-109, 122, 342, 405
Universal Joints 276, 342

MECHANICAL PARTS & DESIGN

Balls 302
Bearing Materials 317
Bearings
Ball..32, 128, 229, 328, 353, 357
Miniature 128
Needle 65
Oil-less 267, 310
Roller ....4th Cover, 14, 32, 35 38-39, 229, 249, 330, 357, 372, 407
Sleeve....262, 267, 317, 392, 433
Bellows.....124, 325, 334, 396
Bi-Metal 268
Bushings 310, 317, 392
Controls.....43, 46, 271, 324
Conveyor Chains 35
Conveyors 35, 251
Counters 17, 434
Decalcomanias 322
Gaskets.....2nd Cover, 36-37, 53 350, 396, 458
Heat Exchangers 347
Inspection Equipment.....269 275, 441
Instruments.....43, 271, 337, 442
Links 262
Lubricants 408
Lubricating Equipment..8, 10, 15 61, 257, 273
Mountings 372
Name Plates.....322, 388, 394
Optical Parts 466
Packings..2nd Cover, 36-37, 48-49 53, 68, 342, 350, 396, 458
Pillow Blocks....32, 35, 38-39, 388
Rod Ends 32
Seals..2nd Cover, 26-27, 36-37, 53 95, 257, Insert facing p. 2 & 28, 323, 350, 376, 382, 396 348, 458
Shims 85, 280
Spindles 372
Springs 92-93, 432
Steam Traps 46
Tables, Dial-feed 443
Thermocouples 43, 271
Thermostats....271, 334, 352, 434
Vibration Dampers Mechanical 124, 379
Vibration Mountings 254 379, 410
Wheels 372
Wire Cloth 311

FASTENING & JOINING TECHNIQUES

Adhesives 106, 415
Bolts.....52, 97, 231, 259, 290 299 418, 426
Brazing Alloy 252
Cam Fasteners 94, 372
Clamps 126
Clips 126
Fastening Methods..58, 72-73, 96 126, 352, 430
Flux 252, 255, 310
Locks 378
Nuts..52, 58, 85, 96, 97, 126, 231 259, 290, 367, 378, 417 418, 426
Pins 52, 352, 426, 430
Retaining Rings 63, 126, 301
Rivets.....58, 97, 259, 426

Index of

PRODUCTS ADVERTISED

In This Issue

Screw Fasteners 96, 444
Screws..52, 87, 231, 259, 290, 299 339, 398, 418, 426
Screw Thread Inserts.....444
Solder 361
Specialty Fasteners (Pipe Hangers, Special Cold Parts, etc.)..42, 58, 94, 96, 126, 231 259, 261, 367, 418
Washers..72-73, 259, 301, 317, 378 426, 429
Welding
Equipment 310, 391
Supplies 4, 60, 310
Welding Nuts 452

MOTORS, ENGINES & CONTROLS

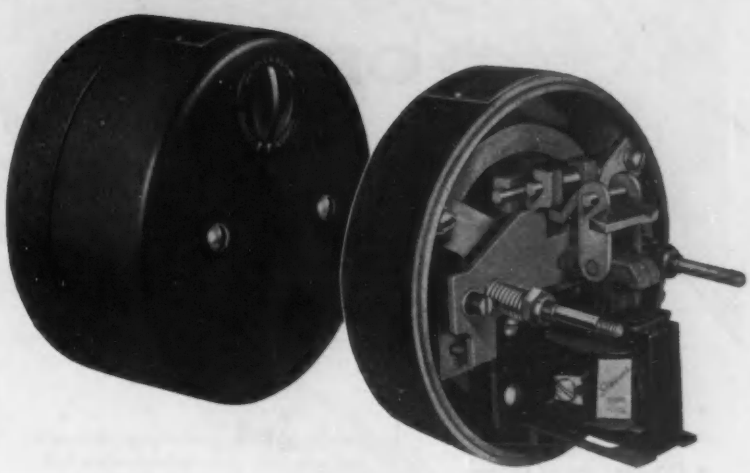
Brake Motors 216, 274
Carburetors 428
Control Motors 114-121, 271
Control Panels & Switchboards 114-121
Controls
Electrical..43, 114-121, 271, 401
Electronic..43, 114-121, 271, 386
Converters.....82, 114-121, 405
Drives, Adjustable Speed 3rd Cover, 84, 114-121
Engine Components (Pistons, Piston Rings, etc.).....389, 430
Engines....288, 322, 354, 389, 405 411, 430
Gear Motors..84, 104-105, 114-121
Generators
A-C 82, 114-121, 274, 409
D-C 82, 114-121, 274, 409
High Frequency 114-121
Inverters 82, 114-121, 466
Motor Reducers....3rd Cover, 82 104-105, 111, 114-121, 243, 263 Insert facing p 325, 335, 409, 419
Motor Starters..28-29, 114-121, 401
Motors, A-C
Fractional..3rd Cover, 13, 20-21 56-57, 66, 70, 82, 84, 91, 104-105 114-121, 216, 225, 233, 263, 274 313, Insert facing p. 325 409, 419
Integral....3rd Cover..13, 20-21 56-57, 66, 84, 91, 104-105 114-121, 216, 225, 233, 243 274, 409
Sub-Fractional .....82, 84, 98 104-105, 114-121, Insert facing p. 325, 331
Motors, D-C
Fractional..3rd Cover, 13, 56-57, 70, 82, 84, 104-105, 114-121 233, 263, 274, 313, Insert facing p. 325, 409, 419, 466
Integral....3rd Cover, 13, 56-57, 84, 104-105, 114-121, 233, 243 274, 409
Sub-Fractional...82, 84, 104-105 114-121, Insert facing p. 325, 331
Motors, High Frequency
Fractional 82
Sub-Fractional 82
Power Packs 114-121
Protective Devices
Motors 114, 121
Servomechanism Components.. 271
Timing Motors ...98, 114-121, 271 278, 394

ELECTRICAL & ELECTRONIC COMPONENTS

Amplifiers 337
Assemblies.....300, 310, 314, 361
Bi-Metal 31
Brushes 48-49, 68, 310
Brush Holders 310, 446
Cable 43, 314, 346

(Continued on Page 460)

BIG NEWS FROM STEARNS FOR MAKERS AND USERS OF FHP MOTORS



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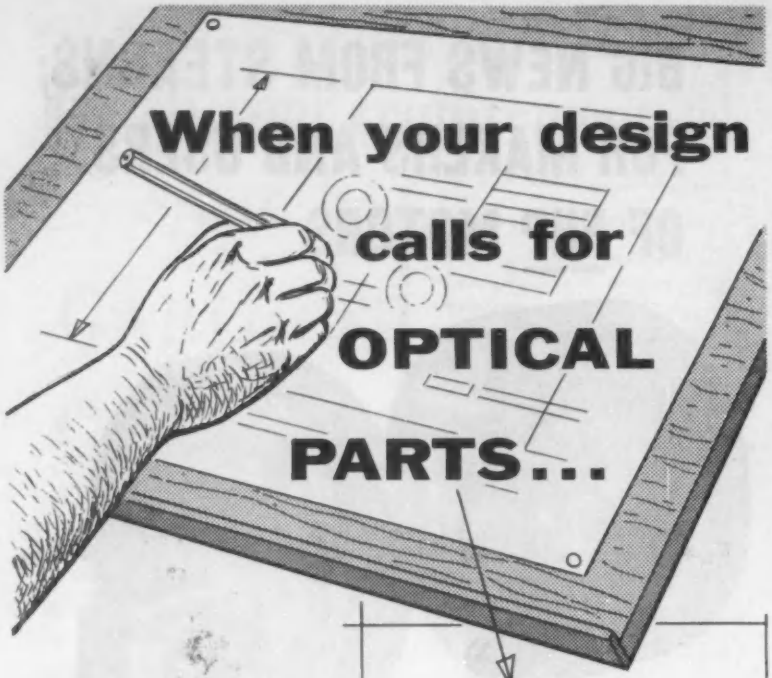

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Index of PRODUCTS ADVERTISED

In This Issue

(Continued from Page 459)

Chokes..Insert between pp. 260 & 261, 296
Circuit Breakers 114-121
Clips 314
Coils 296, 328, 438
Collector Rings 31, 310
Computers 337, 373
Connectors....4, 60, 300, 310, 314 348, 373, 465
Contactors .....Insert between pp. 32 & 33, 369
Contacts & Contact Materials 4, 31, 60, 300, 310, 361
Controllers..43, Insert between pp. 96 & 97, 114-121, Insert between pp. 260 & 261
Controls
Electrical..28-29. Insert between pp. 32 & 33, 43, 46, Insert between pp. 96 & 97, 114-121, Insert between pp. 260 & 261, 271, 316 401
Electronic....43, Insert between pp. 96 & 97, 114-121, 271
Cords 314, 346
Dynamotors 82, 466
Electrical & Electronic Components, Custom Made..... 43 302, 314, 316, 408, 465
Electrodes 310
Electronic Tubes 466
Galvanometers 337
Heating Units....43, 114-121, 316 338, 426
Hermetic Seals 314, 422
Instruments.....43, 264, 271, 337
Insulating Varnish..Insert between pp. 356 & 357 (Silicone)
Insulation..43, 332-333. Insert between pp. 356 & 357 (Silicone)
Insulators 314, 378
Inverters 466
Magnets 459
Markers, Wire & Insulation.. 442
Meters 43, 264, 465
Overload Relays...Insert between pp. 96 & 97
Paper Insulation 332-333
Plugs 314
Porcelain 378
Potentiometers 358
Reactors, Electrical 296
Recorders 43, 337
Rectifiers.....4, 60, 114,-121
Regulators ....Insert between pp. 32 & 33
Relays....Insert between pp 32 & 33, 43, Insert between pp. 96 & 97, 114-121, 271- 278, 302, 314 320, 367, 369, 371, 373, 380
Resistors....4, Insert between pp. 32 & 33, 60, Insert between pp. 56 & 97, Insert between pp. 260 & 261
Rheostats..60, Insert between pp. 96 & 97, 114-121, Insert between pp. 260 & 261, 465
Sleeves & Tubing, Electrical.. 316
Solenoids..74, Insert between pp. 96 & 97, 271, 296, 300, 366 369, 378, 406
Switches..4, 60, 76-77, Insert between pp. 96 & 97, 114-121 Insert between pp 260 & 261, 271 284, 314, 367, 373, 402
Tapes, Insulating...Insert between pp. 356 & 357 (Silicone), 436
Telephones 296
Terminals & Terminal Boards Insert between pp. 96 & 97 422, 465
Thermocouples 43, 271
Thermostats.....30, Insert between pp. 96 & 97, 271, 316, 427 432, 434
Timers....Insert between pp. 96 & 97, 98, 114-121, 271, 278 302, 340

Index of

PRODUCTS ADVERTISED

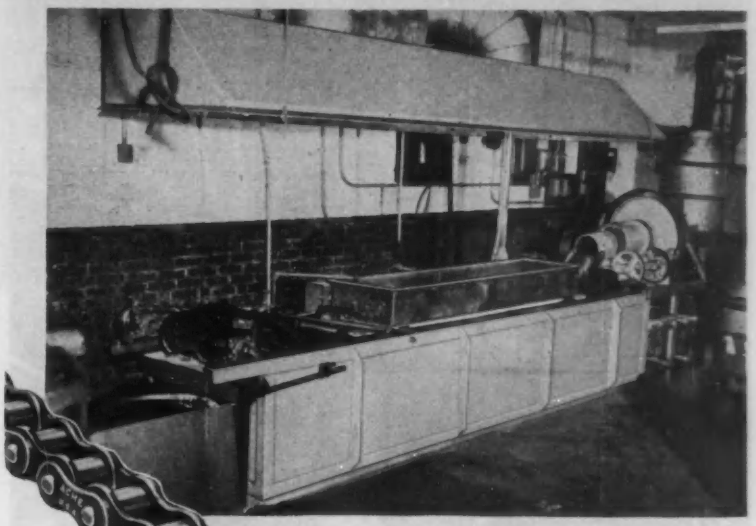
In This Issue

Transducers 337
Transformers.....104-105, 114-121, 296
Wire & Cable.....43, 314, 346, 435
Wire Devices.....43, 300, 314
Wiring Harnesses.....43, 296, 314

HYDRAULIC & PNEUMATIC EQUIPMENT

Actuators
  Hydraulic 271, 413
  Pneumatic 271, 413
Accumulators 345, 414
Air Motors.....271, 374, 432
Assemblies
  Hydraulic.....59, 271, 327, 374
  Pneumatic 271, 327
Ball Joints 451
Boosters.....345, 359, 414
Clamps 377, 429
Compressors 381, 405
Connectors
  Hose.....43, 124, 327, 381
  Tube 124, 327, 381
Controls
  Hydraulic...43, 59, 90, 271, 355, 359, 374, 413, 414
  Pneumatic.....90, 271, 355, 413
Couplings
  Hose...26-27, 124, 327, 381, 385
  Tube.....26-27, 124, 327, 355, 381, 385
Cylinders
  Hydraulic ..59, 90, 250, 314, 324, 336, 345, 355, 363, 414
  Pneumatic....90, 250, 314, 324, 345, 355, 377, 385, 416
Diaphragms ...2nd Cover, 308, 458
Drives, Variable Speed..... 59
Filters
  Air 364, 400
  Hydraulic.....281, 364, 400, 414
Floats 284
Flow Measurement 245, 271
Flow Regulators 316
Gaskets....2nd Cover, 36-37, 53, 245, 308, 350, 376, 458
Heat Exchangers 347
Hose & Tubing....36-37, 124, 327, 381, 383, 385
Instruments
  Hydraulic 271
  Pneumatic 271
Lubricants 408
Meters 271
Motors
  Air 416
  Hydraulic..59, 336, 342, 363, 374
Packings....2nd Cover, 36-37, 53, 308, 342, 350, 458
Piping 245, 286
Power Packs 59, 90, 363, 414
Pressure Switches 413
Pumps
  Air 364
  Liquid.....59, 81, 286, 292, 342, 359, 363, 364, 374, 387, 400, 405, 420, 439, 446
  Vacuum 364, 441
Regulators
  Hydraulic 59, 359, 414
  Pneumatic 385
Seals ....2nd Cover, 26-27, 36-37, 53, 95, 257, 308, 323, 350, 382, 438, 458
Shock Absorbers 291
Strainers ..245, 271, 284, 364, 385
Swivel Joints 245, 272, 324, 381, 383
Valves Controls, Motorized.... 122
Valves
  Air 1, 90, 245, 271, 283, 284, 324, 366, 383, 385, 436
  Hydraulic.....26-27, 59, 61, 90, 245, 271, 283, 284, 316, 324, 336, 359, 363, 366, 374, 381, 383, 414, 436
Washers 308

No. 3 - Precision Operations in the Manufacture of ACME Chains



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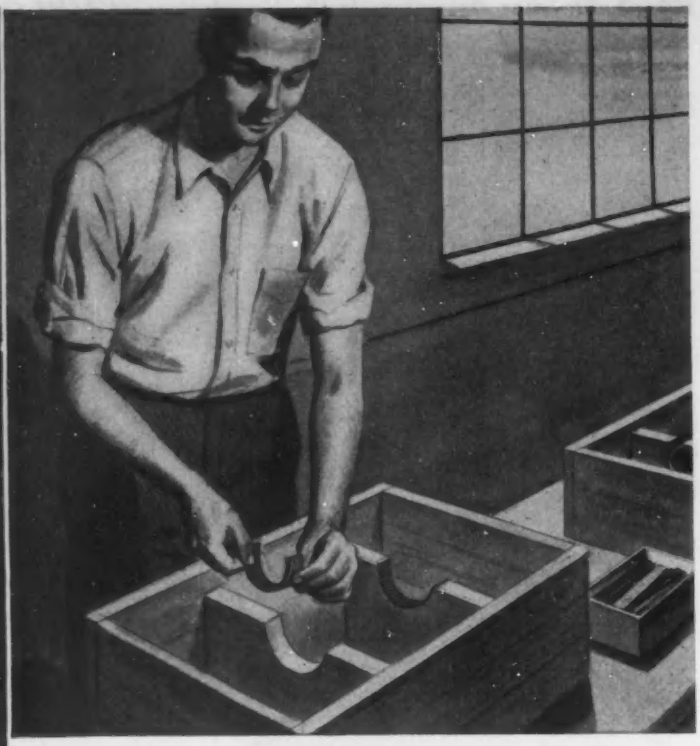

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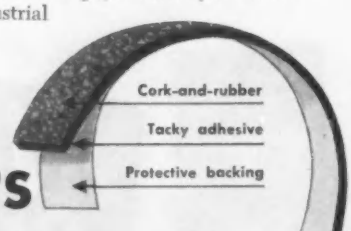

ARMSTRONG'S DK-153 TAPE

INDEX TO ADVERTISERS

This index is published as a convenience to the readers. Every care is taken to make it accurate but PRODUCT ENGINEERING assumes no responsibility for errors or omissions.

Acme Chain Corp. 461
Acushnet Process Co. 256
Advance Electric & Relay Co.. 380
Aeroquip Corp. 381
Aircraft-Marine Products, Inc. 373
Ajax Flexible Coupling Co.... 251
Alemite 61
All American Engineering Co.. 350
Allegheny Ludlum Steel Corp.. 423
Allen-Bradley Co.
Insert between pp. 96 & 97
Allen Mfg. Co. 339
Allied Research Products, Inc. 386
Allis-Chalmers Mfg. Co.
Insert between pp. 32 & 33, 81
Allmetal Screw Pdts. Co., Inc. 426
Aluminum Industries, Inc..... 247
American Chemical Paint Co.. 265
American Cystoscope Makers, Inc. 348
American Gear & Mfg. Co.... 99
American Hard Rubber Co.... 258
American Insulator Corp..... 375
American Nickeloid Co.
Insert between pp. 388 & 389
American Radiator & Std. Sanitary Corp. 421
American Screw Co. 87
American Steel & Wire Div., U. S. Steel Corp. 92-93
American Welding & Mfg. Co. 235
Anchor Plastics Co., Inc..... 320
Anker-Holth Div., Wellman Engineering Co. 250
Arens Controls, Inc. 324
Armco Steel Corp. 220
Armstrong Cork Co....53, 79, 462
Arwood Precision Casting Corp. 338
Atlantic Screw Works, Inc.... 87
Austenal Laboratories Inc.... 282
Automatic Steel Products, Inc. 422
Automatic Switch Co. 283
Automotive Gear Works, Inc.
Insert facing p. 324
Avien-Knickerbocker, Inc. 434

Bakelite Co., Union Carbide & Carbon Corp. 47
Barco Mfg. Co. 272
Barkadale Valves 413
Barry Corp. 254
Bausch and Lomb Optical Co.. 460
Bead Chain Mfg. Co. 307
Bellows Co. 416
Bendix-Redbank Div., Bendix Aviation Corp. 466
Bendix-Skinner Div., Bendix Aviation Corp. 400
Bethlehem Steel Co. 88, 97
Bishop & Co., J. Platinum Works, Stainless Steel Pdts. Div. 425
Blake & Johnson Co. 87
Bodine Electric Co.
Insert facing p. 325
Bound Brook Oilless Bearing Co. 267
Bower Roller Bearing Co..... 407
Brainard Steel Div. Sharon Steel Corp. 329
Bridgeport Brass Co. 102
Bristol Co., Socket Screw Div. 398
Brook Motor Corp. 66
Brooks & Perkins, Inc. 336
Brown Engineering Co. 328
Bruning Co., Inc., Chas...260, 293
Brush Electronics Co. 269
Bunting Brass & Bronze Co... 392
Burlington Instrument Co..... 264

C. E. M. Co. 352
Calidyne Co. 304
Cambridge Wire Cloth Co..... 448
Camcar Screw & Mfg. Corp... 87
Cameron Iron Works, Inc..... 237
Camloc Fastener Corp. 261
Cannon Electric Co. 300
Carboloy Dept. of General Electric Company 438, 463
Carpenter Steel Co. 360
Carpenter Steel Co., Alloy Tube Div. 86
Central Screw Co. 87
Century Electric Co. 409
Chace Co., W. M. 268
Chase Brass & Copper Co., Inc. 368

INDEX TO ADVERTISERS

Chain Belt Co. 35
Chemical Corp. 270
Chicago Rawhide Mfg. Co. 2nd Cover
Chicago Thrift-Etching Corp. .. 394
Chikaan Co. 383
Chrysler Corp. Industrial Engine Div. 405
Ciba Co., Araldite Div. 67
Cincinnati Gear Co. 264
Clapp and Poliak, Inc. 412
Clare & Co., C. P. 371
Clark Controller Co. 401
Cleveland Pneumatic Tool Co. . 291
Cleveland Welding Co., subs. Amer. Machine & Foundry Co. 447
Cleveland Worm & Gear Co. . 312
Clifford Mfg. Co. 325
Climax Molybdenum Co. 408
Cold Metal Products Co. 40-41
Columbia-Geneva Steel Div. U. S. Steel Corp. 92-93
Cone-Drive Gears Div. Michigan Tool Co. 335
Connecticut Hard Rubber Co. . 380
Consolidated Engineering Corp. 337
Continental Diamond Fibre Co. 287
Continental Rubber Works 370
Continental Screw Co. 87, 231
Coto-Coil Co., Inc. 438
Cramer Co., Inc., R. W. 278
Crane Co. 245
Crane Packing Co. 396
Crucible Steel Co. of America 341
Curtis Universal Joint Co., Inc. 276

DeJur-Amsco Corp. 465
Delco Products Div., Gen. Motors Corp. 91
Denison Engineering Co. 374
Detroit Controls Corp. 378
Dexter Machine Products, Inc. 372
Diehl Manufacturing Co., Inc. . 13
Dillon & Co., Inc., W. C. 324
Dodge Mfg. Corp. 388
Doerr Electric Corp. 216
Dormeyer Industries 328
Dostal Foundry & Machine Co. 306
Dow Corning Corp. Insert between pp. 356 & 357
Driv-Lok Pin Co. 430
Drop Forging Association 305
Dudek & Bock Spring Mfg. Co. 432
duPont de Nemours & Co. Inc. E. I. Neoprene 83
duPont de Nemours & Co., Inc. E. I. Pigments Dept. 69
duPont de Nemours & Co., Inc. E. I. (Plastics) Insert between pp. 64 & 65
Durakool, Inc. 284
Durametallic Corp. 438

Eagle Lock Co. 87
Eastman Kodak Co. Special Products Sales Div. 277
Eastman Mfg. Co. 327
Elmco Corp. 432
Elastic Stop Nut Corp. of America 85
Elco Tool & Screw Corp. 87
Electrical Engineering & Mfg. Corp. 331
Electric Wheel Co. 372
Electro Switch Corp. 402
Emerson Electric Mfg. Co. 233
Engineering Research Assoc. Inc. 428
English & Company, John A. . 442

Fairchild Aircraft Div., Fairchild Engine & Airplane Corp. 424
Fairfield Mfg. Co. 270
Falk Corp. 243
Fawick Airflex Div., Federal Fawick Corp. 397
Federal Mogul Corp. (Equipment) 317
Felters Co. 455
Fenwal, Inc. 427
Firestone Plastics Co., Chemical Sales Div., Div. of Firestone Tire & Rubber Co. ..22-23
Flexonics Corp. 124
Flower Mfg. Co., D. B. 446
Foote Bros. Gear & Machine Corp. 111
Foote Gear Works, Inc., Brad 99
Ford Motor Co., Industrial Engine Dept. 411
Frenchtown Porcelain Company 298

(Continued on page 464)

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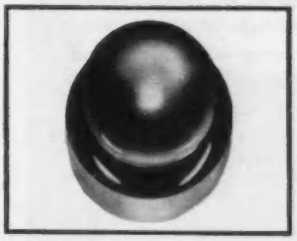

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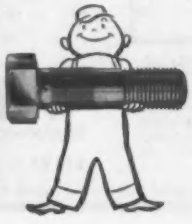

Exclusive New England Representatives for Cleveland Cap Screw Co.

INDEX TO ADVERTISERS

(Continued from page 463)

Fulton Sylphon Div., Robertshaw-Fulton Controls Co.... 334
Funk Aircraft Co..... 430
Fusite Corp. 422

Galland-Henning Nopak Div.. 324
Garlock Packing Co..... 458
Garrett Co. Inc., George K.... 429
Gear Specialties, Inc..... 75
General American Transportation Corp., Plastics Div..... 399
General Controls Co..... 271
General Electric Co. Apparatus Dept. 114-121
Gerotor May Corp..... 342
Geuder, Paschke & Frey Co. Contract Div. 393
Gits Bros Mfg. Co..... 257
Gleason Works 6
Goodrich Co., B. F. (Rivnut).. 58
Graham Transmissions, Inc... 297
Graphite Metallizing Corp..... 310
Graton & Knight Co..... 308
Gray Iron Founders' Society, Inc. 431
Great Lakes Screw Corp..... 87
Greer Hydraulics Inc..... 414
Gries Reproducer Corp..... 428
Guardian Electric Mfg. Co.... 359

Handy & Harman..... 252
Hansen Mfg. Co., Inc..... 394
Harper Co., H. M..... 87
Harvey Aluminum Sales, Inc.. 279
Haydon Co., A. W..... 302
Haynes Stellite Co., Div. of Union Carbide & Carbon Corp. 404
Heli-Coil Corp. 444
Helm Co. 32
Higgins Ink Co., Inc..... 400
Hoover Co., Electric Motor Div. 20-21
Howard Industries, Inc..... 82
Hunter Douglas Corp..... 403
Hyatt Bearings Div. General Motors Corp. 14
Hydraulic Press Mfg. Co. Hydraulic Power Division.. 363
Hydreco Div., The New York Airbrake Co. 336

Imperial Pencil Tracing Cloth 394
Improved Seamless Wire Co. Inc. 408
Indiana Gear Works..... 445
Industrial Equipment Co..... 298
Industrial Timer Corp..... 340
Insulation and Wires, Inc..... 255
International Nickel Co., Inc. 33, 42
International Packings Corp... 308

Johns-Manville Corp. (Packings) 323
Johnson Bronze Co..... 433
Johnson Machine Co., Carlyle 16

Kaiser Aluminum & Chemical Corp. 321, 343-344
Kaydon Engineering Corp..... 229
Kellogg Co., M. W., Chemical Mfg. Div.
Insert between pp. 420 & 421
Kilian Mfg. Corp..... 328
Koppers Co., Inc. Plastics Div. 415
Koven & Bro., Inc., L. O..... 362
Kraissl Co. Inc..... 364

Lamb Electric Co..... 419
Laminated Shim Co., Inc. (Shim) 280
Lamson & Sessions Co.....87, 259
LaSalle Steel Co.....24-25
Lebanon Steel Foundry.....54-55
Leland Electric Co., Div., The American Machine & Foundry Co. 56-57
Le Roi Co..... 354
Lewellen Mfg. Co..... 318
Lincoln Electric Co..... 310
Linear, Inc. 342
Link Belt Co.....11, 38-39
Lion Fasteners, Inc..... 372
Logansport Machine Co., Inc. 355
Lord Mfg. Co..... 379
Lovejoy Flexible Coupling Co. 342
Lycoming Divisions—Avco Mfg. Corp. 389

McGill Mfg. Co., Inc..... 249
McGraw-Hill Book Co., Inc... 448
M B Mfg. Co., Inc..... 410
Madison-Kipp Corp..... 273

INDEX TO ADVERTISERS

Mahon Co., R. C. 347
Makepeace Co., D. E. 361
Mallory & Co., Inc., P. R. 4, 60
Manhattan Rubber Co. 36-37
Manheim Mfg. & Belting Co. ... 239
Markel Products Co. 436
Marsh Instrument Co. 442
Marvel Engineering Co. 281
Massachusetts Gear & Tool Co. 408
Master Electric Co. (Speed-master) .....3rd Cover
Mayline Co. 348
Mead Specialties Co. 377
Meehanite Metal Corp. 18-19
Mercury Clutch Div., Automatic Steel Products Inc. ... 422
Metals & Controls Corp. General Plate Div. 31
Metals & Controls Corp. Spencer Thermostat Div. 30
Meyercord Co., Name Plate Div 322
Michigan Steel Casting Co. 384
Michigan Tool Co. Cone Drive Div. 335
Micrometrical Mfg. Co. 422
Micro Switch Div., Minneapolis-Honeywell Regulator Co. 76-77
Midland Steel Products Co. 452
Miller Fluid Power Co. 345
Minnesota Mining & Mfg. Co.. 106
Monsanto Chemical Co. 218
Moraine Products Div. General Motors Corp. 390
Morse Chain Co. 89
Mt. Vernon Die Casting Corp. 34
Mueller Brass Co. 275

National Acme Co. 406
National Band & Tag Co. 442
National Lead Co. 51
National Lock Co. 87
National Lock Washer Co. 301
National Malleable & Steel Casting Co. 315
National Motor Bearing Co., Inc 95
National Pneumatic Co., Inc. .. 313
National Screw & Mfg. Co. 87
National-Standard Co. 435
National Vulcanized Fibre Co. 332-333
Naugatuck Chemical Div. of U. S. Rubber Co. 103
Newark Wire Cloth Co. 311
New Departure Div., Gen. Motors Corp. 128
New Jersey Zinc Co. 12
New York Airbrake Co. 336
New York Belting & Packing Co. (Gilmer Products) 44-45
Nicholson & Co., W. H. 284
Nordberg Mfg. Co. 288
Norgren Co., C. A. 10, 15
North American Research Laboratories, Inc. 446
Nutt-Shel Co. 96
Nylok Corp. 290

O & S Bearing & Mfg. Co. 262
Ohio Gear Co. 442
Ohio Seamless Tube Division of Copperweld Steel Co. 241
Ohmite Mfg. Co. Insert between pp. 260 & 261
O'Neil-Irwin Mfg. Co. 318
Ortman-Miller Machine Co. 314

Packard Electric Div. General Motors Corp. 70
Palnut Co. 378
Parker Appliance Co. 26-27
Parker-Kalon Corp. 87
Parker Rust Proof Co. 8
Peerless Electric Co., Motor Div. 225
Peerless Photo Products, Inc. ... 71
Penn Metal Co., Inc. 326
Perkins Machine & Gear Co. 440
Pheoll Mfg. Co. 87
Philadelphia Gear Works, Inc. 122
Pioneer Pump Div. of Detroit Harvester Co. 292
Pittsburgh Gear Co. 99, 364
Pittsburgh Plate Glass Co. Fiber Glass Div. 50
Platecoil Div. of Tranter Mfg., Inc. 437
Pneu-Trol Devices Inc. 436
Porcelain Enamel Institute Inc. 365
Power Products Corp. 322

(Continued on page 466)

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Gun Cathode Current	28 ma. D.C.
Tuner Cathode Current	10 ma. D.C.

ELECTRICAL CHARACTERISTICS

Heater Voltage (A.C. or D.C.)	6.3 volts
Heater Current	.755 amps.
Thermal Tuning Range	23216 to 24751 Mc/Sec.
Min. Power Output at 23504 Mc/Sec.	8.5 mW.
Min. Power Output at 23984 Mc/Sec.	10.0 mW.
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• Dimensions: Maximum seated height 2¼" • Base: Small Octal 8-Pin, B8-21, Low Loss Phenolic Wafer • Coupling to Wave Guide: Direct, by means of an insulating fitting • Cooling: Convection • Mounting Position: Any • Cavity: Silver Plated Steel (integral within the bulb) • Bulb: Metal • Output Window: Low loss glass

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Canadian Distributor: Aviation Electric Ltd., P.O. Box 6102, Montreal, P.Q.

INDEX TO ADVERTISERS

(Continued from page 465)

Precision Rubber Products Corp. 382
Preastite Engineering Co..... 467
Process Gear Co., Inc..... 319
Product Engineering 112-113
Production Instrument Co.... 434

Racine Hydraulics & Machinery Inc. 359
Raybestos-Manhattan Inc. ...36-37
Equipment Sales Div.
Manhattan Rubber Div.
Packings Div.
Reeves Pulley Co.....108-109
Reliance Electric & Engineering Co. 263
Republic Steel Corp. Bolt and Nut Div. 417
Republic Steel Corp., Steel & Tubes 253
Revere Copper & Brass Inc..2, 64
Revere Corp. of America..... 43
Rhode Island Tool Co..... 464
Richardson Co. 285
Riverside Mfg. & Electrical Supply Co. 314
Rivett Lathe & Grinder, Inc... 90
Robbins & Myers, Inc..... 439
Robertshaw Thermostat Div. Robertshaw-Fulton Controls Co. 352
Rochester Products Div. Gen. Motors Corp..... 110
Rockford Clutch Div. Borg Warner Corp. 360
Rockford Screw Products Co.. 87
Rollway Bearing Co., Inc..... 330
Roper Corp., Geo. D..... 420
Ross Operating Valve Co..... 1
Roth Rubber Co..... 376
Rubatex Division, Great American Industries, Inc. Insert facing p. 293
Russell, Burdsall & Ward Bolt & Nut Co..... 418
Ruthman Machinery Co..... 400

SKF Industries, Inc..... 357
Safety Socket Screw Co..... 299
Saginaw Steering Gear Div General Motors Corp..... 351
Sandvik Steel, Inc..... 349
Sarco Co. Inc..... 46
Schrader's Sons, A..... 385
Sciaky Brothers 391
Scintilla Div. Bendix Aviation Corp. Electrical Conn. 348
Scovill Mfg. Co..... 87
Screw Research Association.. 87
Service Machine Co..... 468
Servospeed Inc. 386
Shakeproof Div. of Illinois Tool Works 72-73
Simmons Fastener Corp. 94
Skinner Electric Valve Div. Skinner Chuck Co..... 366
Society of the Plastics Industry 426
Soreng Products Corp..... 74
Southern Screw Co..... 87
Southington Hdwe. Mfg. Co... 87
Sparta Mfg. Co..... 360
Square D Co.....28-29
Standard Pressed Steel Co.... 52
Star-Kimble Motor Division Miehle Printing Press & Mfg. Co. 274
Stearns Magnetic, Inc..... 459
Stephens-Adamson Mfg. Co. Sealmaster Bearings Div... 353
Sterling Bolt Co..... 87
Sterling Engineering Co., Inc. Div. American Machine & Foundry Co. 320
Stewart Warner Corp. (Alemite) 61
Stewart Die Casting Div Stewart Warner Corp..... 80
Stokes Machine Co., F. J..... 441
Strom Steel Ball Co..... 302
Stronghold Screw Products, Inc. 87
Superior Steel Corp. Insert facing p. 292
Sweet's Catalog Service..... 334
Synthane Corp. 294-295

Taylor Fibre Co..... 395
Technology Instrument Corp. 358
Telechron Dept., General Electric Co. 98
Tennessee Coal & Iron Div., U. S. Steel Corp.....92-93
Thiokol Chemical Corp..... 266

INDEX TO ADVERTISERS

Thomas Flexible Coupling Co. 306
Thompson-Bremer Company Sub. of American Machine & Foundry Co. 367
Timken Roller Bearing Co. (Industrial) .....4th Cover
Timken Roller Bearing Co. (Steel & Tubes)..... 107
Tinnerman Products Inc..... 126
Torrington Co. (Needle Bearing) 65
Torrington Co. (Specialty)... 62
Tourek Mfg. Co., J. J..... 451
Tri-Clover Machine Co..... 286
Twin Disc Clutch Co..... 303

Union Carbide & Carbon Corp. Bakelite Company 47
Haynes Stellite Company... 404
United Electric Controls Co... 434
United Mfg. Co..... 354
U. S. Gasket Co..... 350
U. S. Graphite Co.....48-49, 68
U. S. Rubber Co..... 103
U. S. Steel Corp.....92-93
U. S. Steel Export Co.....92-93
Universal Clay Products Co... 378
Universal Drafting Machine Co. 338

V & O Press Co. Div. Emhart Mfg. Co. 443
Van Cleef Bros., Inc..... 436
Veeder-Root Inc. 17
Vickers Inc. 59
Viking Pump Co. 446
Vulcan Electric Co..... 338

Wagner Electric Corp.....104-105
Waldes-Kohinoor Inc. 63
Wales-Beech Corp. 87
Warner Electric Brake & Clutch Co. (Industrial Division) 100-101
Waterbury Rolling Mills, Inc. 289
Waterman Engineering Co.... 316
Watlow Electric Mfg. Co..... 316
Webster Electric Co., Oil Hydraulics Div. 387
Wellman Engineering Co. Anker-Holth Div. 250
Western Felt Works..... 356
Westinghouse Electric Corp. 84, 450
Wheeler Insulated Wire Co... 296
White Dental Mfg. Co., S. S. 456-457
Whitney Blake Co..... 346
Wichita Falls Foundry & Machine Co., Inc..... 227
Wiegand Co., Edwin L. Ind. Div. 426
Wilcolator Co. 432
Wisconsin Motor Corp..... 430
Wolverine Tube Div. Calumet & Hecla Inc..... 78
Worcester Gear Works, Inc... 346
Wyman-Gordon Co..... 309

Zenith Carburetor Div. Bendix Aviation Corp. 428

■

PROFESSIONAL SERVICES ... 452

SEARCHLIGHT SECTION
(Classified Advertising)
H. E. Hilty, Mgr.

EMPLOYMENT
Positions Vacant 453, 454
Positions Wanted 454
Selling Opportunities Wanted... 454
Employment Agencies 453

SPECIAL SERVICES
Contract Work 452

■

Advertisers' Index starts on 462
Products Index starts on.. 455

Your 1955 Models Require New Sealing Compounds Today

Sealing Compounds, Adhesives and Coatings for air conditioning, aircraft, appliances, aluminum windows, automobiles, breweries, bridges, cold storage, concrete curing, communications, dams and locks, excavation work, fuel tanks, greenhouses, highways, housing, railroad cars, refrigerators, reservoirs, sewers, storage tanks, trailers, trucks, and many other products and industries.

As often as designs change in automobiles, air conditioners, refrigerators and hundreds of other products . . . new sealing problems arise. Staple, stock-in-trade sealants are not always the most effective answer.

Presstite's Research and Development Laboratories, specializing exclusively in sealing compounds for more than 24 years, thrive on the challenge to formulate new sealants for new products, new models, new requirements.

If you contemplate new, improved models, remember to protect the quality and performance you so carefully plan. Consult our experienced sales engineers, who will be glad to work closely with you in recommending or having our laboratories formulate the very best sealant for your needs.

PRESSTITE SEALING COMPOUNDS

In Canada: Railway & Power Engineering Corp., Ltd.

PRESSTITE ENGINEERING COMPANY

3750 Chouteau Ave. **St. Louis 10, Mo.**

EXTRAS at no extra cost

★ extra adjustment of ram
★ extra throat depth
★ extra die space
★ extra stroke

These are but a few of the EXTRAS you get when you buy a SEMCO PRESS BRAKE Sizes— 6 foot and 8 foot

Motorized ram adjustment available

Extra quality, accuracy and strength is assured as the extra heavy hot rolled steel frame is of a single weldment normalized before machining. All parts are engineered and manufactured for interchangeability and accuracy.

The one piece forged alloy steel crankshaft is your security of strength alignment and balance. There is no compromise with quality.

Every feature of construction evolves toward ease of operation and sturdiness for long hard service.

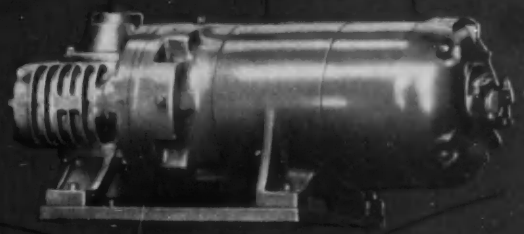
All adjustments are designed for utmost convenience and operators naturally select the SEMCO Press Brake when they have a choice. You will wonder how SEMCO provides so much for so little cost.

Write today for fully illustrated color literature describing the Models 600 and 800 SEMCO PRESS BRAKES. Also ask for BRAKE DIE literature describing SEMCO 34 year BRAKE DIES. Contact your local machinery dealer.

SEMCO

SERVICE MACHINE CO. INC.

182 Miller Street • Elizabeth 4, New Jersey

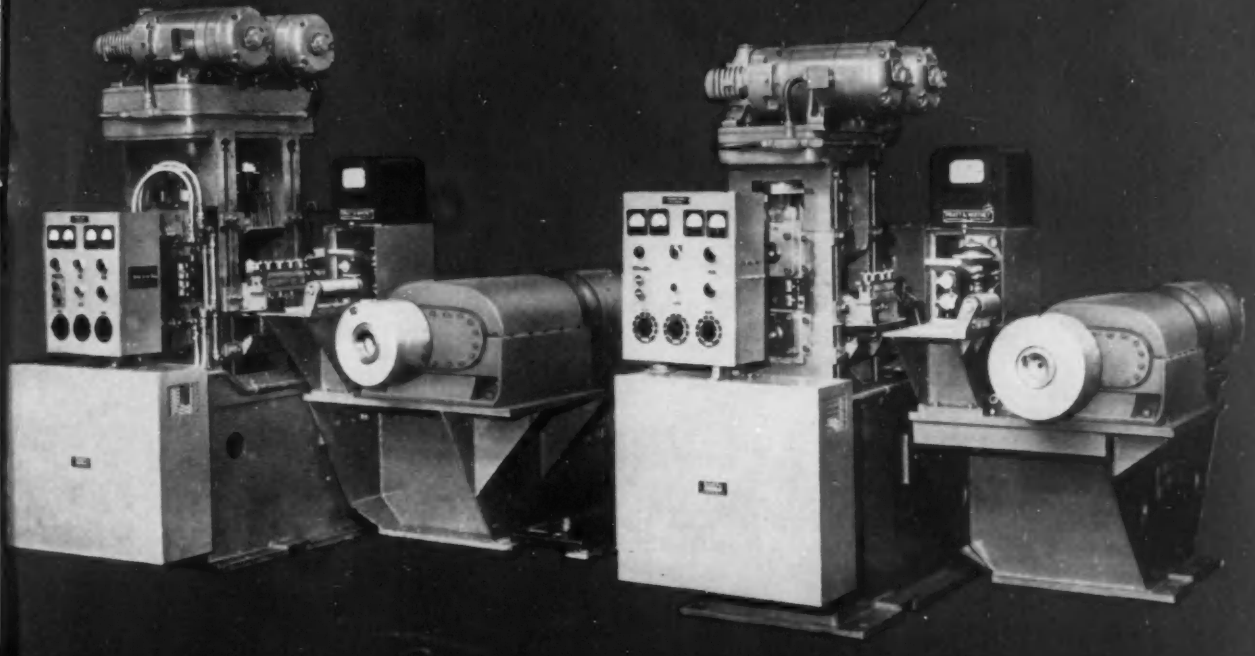


See how easily the standard electric motor, standard gear reduction, standard electric brake combine into a drive that gives the RIGHT horsepower, the RIGHT shaft speed, the RIGHT features . . . all in one compact unit. Nowhere else will you find power units that are so flexible, so easily adaptable, and in such a wide range of types and ratings.

Master power drives are available in thousands and thousands of ratings (⅛ to 400 HP) . . . in open, enclosed, splash proof, fan cooled, explosion proof . . . horizontal or vertical . . . for all phases, voltages and frequencies . . . in single speed, multi-speed and variable speed types . . . with or without flanges or other special features . . . with 5 types of gear reduction up to 430 to 1 ratio . . . with electric brakes . . . with fluid-drive . . . with mechanical or electronic variable speed units . . . and for every type of mounting . . . Master has them all and so can be completely impartial in helping you select the one best power drive for you.

standard units easily combine into special purpose drives

THE MASTER ELECTRIC COMPANY • DAYTON 1, OHIO



Bores, mills, drills, planes, shapes, gets precision from over 100 TIMKEN® bearings

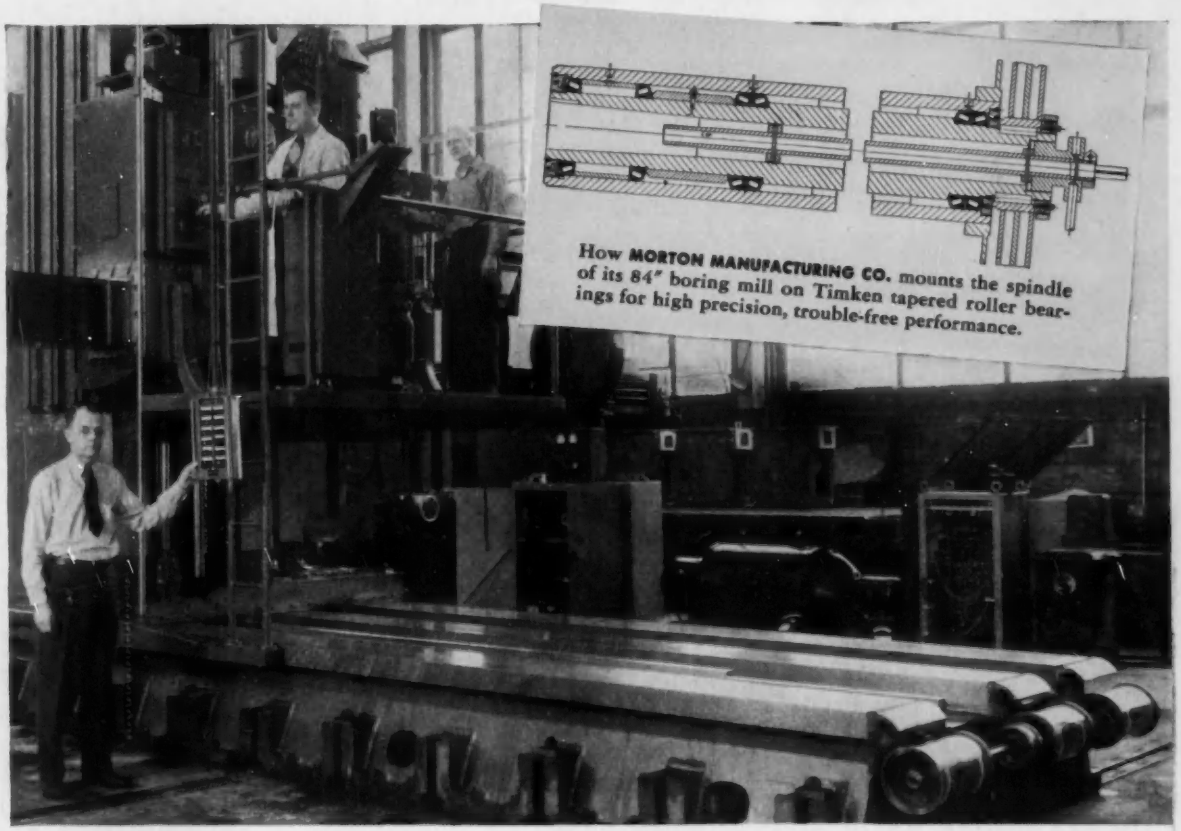
THIS Morton 84" boring mill not only does all the normal operations of boring, milling and drilling, but is fitted with a shaper head so it can do heavy draw-cut or push-cut planing and shaping operations. And it keeps its high precision during them all with more than 100 Timken® tapered roller bearings. They're located in the spindle, saddle, column, feed drive, traverse drive and spindle drive box.

Timken bearings have tapered construction that lets them take both radial and thrust loads, permits pre-loading to any desired degree. Deflection and end-play are minimized. Gears mesh smoothly. Long-lasting accuracy is assured.

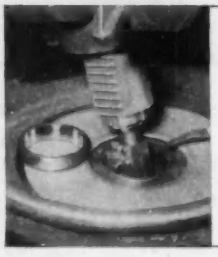
The true rolling motion and incredibly smooth surface finish of Timken precision bearings practically eliminate friction. Timken bearings hold housings and shafts concentric, making closures more effective. Lubricant stays in—dirt stays out. Maintenance time and lube costs are cut.

Be sure to specify Timken precision bearings for the machine tools you build or buy. Look for the trade-mark "Timken" on every bearing. The Timken Roller Bearing Company, Canton 6, Ohio. Canadian plant: St. Thomas, Ontario. Cable address: "TIMROSCO".

This symbol on a product means its bearings are the best.



How **MORTON MANUFACTURING CO.** mounts the spindle of its 84" boring mill on Timken tapered roller bearings for high precision, trouble-free performance.



FINISHED TO CLOSER TOLERANCES

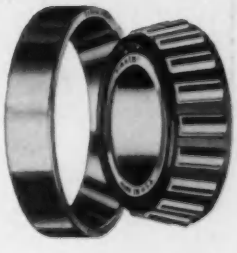
Finishing to incredible smoothness accounts for much of the precise, smooth rolling performance of Timken bearings. This honing operation is typical of the amazingly accurate manufacturing methods at the Timken Company.

The Timken Company is the acknowledged leader in: 1. advanced design; 2. precision manufacturing; 3. rigid quality control; 4. special analysis steels.

TIMKEN

TRADE-MARK REG. U. S. PAT. OFF.

TAPERED ROLLER BEARINGS



NOT JUST A BALL ◯ NOT JUST A ROLLER ⬭ THE TIMKEN TAPERED ROLLER ⬭ BEARING TAKES RADIAL ⬭ AND THRUST ⬭ LOADS OR ANY COMBINATION ⬭